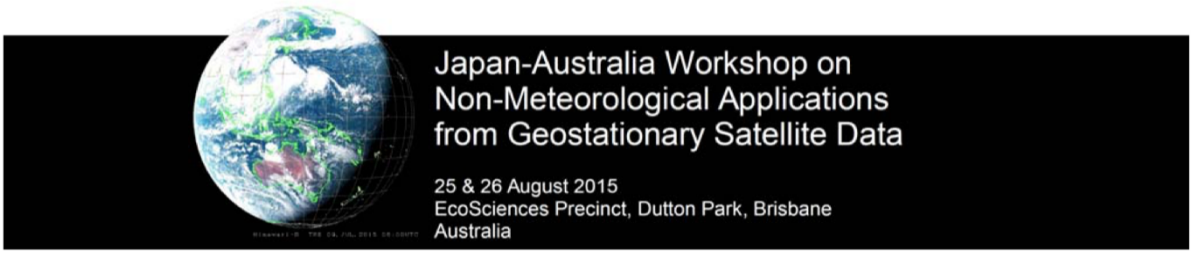

Brief presentation highlights

v1.0, 10 Sep 2015)

Opening session

- **Process and Context (S. Ward, Symbios):** Himawari-8 (launched by Japan) is the first of a new generation of geostationary imagers that promises to open up new application areas, and the purpose of this workshop is to discuss the opportunities, limitations, resources and personnel to realise the potential – making the most of Japan's data streams, and Australia's applications capabilities.
- **Advanced Performance of Himawari-8 in Operation (T. Kurino, JAXA):**Himawari-8 has become operational and is in good health, with Himawari-9 planned for launch in 2016. Both have 15-year planned operational lifespans. The number of channels is increasing from 5 (MTSAT) to 16, and with resolution from 0.5-2.0 kmthe satellite will produce whole disk Earth images every 10 minutes, down to every 2.5 minutes for targeted areas.Data flows via both HimawariCast (spacecraft downlink, MTSAT resolutions 1-4km) and HimawariCloud (Internet, full resolution). Data latency for HimawariCloud will be about 7 minutes after observation start time, and will complete within 4-5 minutes of observation end. There are several historical data servers in operation or envisioned in support of R&D users. The image navigation accuracy is 0.3 pixels, and the image co-registration relative error is on the order of 0.05-0.27 pixels. An update of calibration coefficients for visible and near-infrared channels has been validated based on comparison with VIIRS as well as with radiative transfer model simulation, which has also improved performance.
- **Introduction of the SAFE initiative (M. Koide, JAXA):**The Space Applications for Environment (SAFE) was established to connect EO data and societal benefit in the Asia-Pacific region via the development of technical prototypes. There are currently six projects ongoing (and there were many in the past) aroundclimate, carbon, water, forestry,sea level, fishing, and agriculture making use of data from many EO sensors and derived products. Sentinel Asia aims to bring the benefits of EO to disaster relief. There is a new project (outside of SAFE and Sentinel Asia) from Japan to develop near real time fire monitoring across Asia using Himawari-8.
- **Australian Operational Processing and Data Access to Himawari-8 (L. Majewski, BoM):**There are multiple channels to access Himawari-8 data – HimawariCast, HimawariCloud, and HimawariConnect (BOM direct link to JMA).

The BOM's first priority is to address their own internal needs, but they are also working to get the data into the hands of other users like the R&D community. Latency from the BOM to its users is as good as three minutes for some images, with an objective of getting product generation down to 10 minutes.Many users prefer images (GEOTIFF and JPEG) and so those are being generated based on GDAL. A lot of software has been created by the GOES-R program which can be applied to the Himawari-8 data streams to generate products. For example volcanic ash products were used in July to help support airline partners during the Bali eruptions. Data is being made available on the National Computational Infrastructure (NCI, Canberra) and the overall approach is to try and bring users to the compute and storage rather than having users download and distribute data.

Atmosphere session

- **Potential of Himawari-8 for Atmospheric Observations (T. Nakajima, Tokai Univ.):**A number of atmospheric products are currently being generated including cloud and aerosol properties and water vapour, with additional products under consideration around solar flux. Algorithms have been developed using LEO data sources, with work on adapting these algorithms to GEO data sources currently being undertaken.
- **Aerosol from MAIAC Algorithm (I. Grant, BoM):**The GOES-R Total Column Ozone algorithm is currently being adapted to Himawari-8 data streams by US scientists.Assimilation of Himawari-8 data into Earth System models (and for validation) should be of benefit to these models. The MultiAngle Implementation of Atmospheric Correction (MAIAC) algorithm simultaneously retrieves aerosol and surface reflectance, and has been applied to a number of data streams to date. Adaptation to Himawari-8 should be considered, and a number of Australian ground station observation networks are available for validation.
- **GEO-LEO Combined Aerosol Retrieval (Y. Qin, CSIRO):**Simultaneous retrieval of aerosol, surface reflectance and BRDF is attractive because of their intimate coupling over land, but a serious challenge is the insufficient number of observations compared with the number of variables. An approach that combines GEO and LEO observations has a significant advantage over a single sensor, single view approach by at least doubling the number of observations.CSIRO has developed a dual view algorithm for AATSR which jointly retrieves aerosol and surface BRDF and has been validated with six years of data from the CSIRO aerosol network. The algorithm has been adapted to Himawari-8 combined with either MODIS or VIIRS, through cross calibration between the paired sensors, and the preliminary validation results presented for the surface reflectance consistency and aerosol were good.
- **Assimilation of Aerosol Information for Air Quality Forecasting (M. Hewson, Univ. of Queensland):** The Commission of Enquiry into the Morwell open cut coal mine fire recommended that the state of Victoria establishes a capability to undertake rapid air quality monitoring in any location in the state, and ensuring

that this data is used inform decision making within 24 hours – and satellite observations are key in realising this recommendation.

Land session

- **Possibility of Land Information Extraction using Himawari-8 Time Series Observation Data (K. Kajiwara, Chiba Univ.):**A specific example around vegetation indices (NDVI, EVI2) has been developed using Himawari-8 data, including fluctuation of these indices throughout the day. This direct observation can replace model information that is currently used to assess daily trends. There are several issues to be considered – cloud detection algorithm for land applications, precise geometric correction, and the large data handling requirements for time series analysis.
- **Surface Reflectance Approaches (I. Grant, BoM):**The Himawari-8 observation geometry is complementary to that of LEOs, including less variation in viewing angle, and could potentially benefit surface reflectance products. At least three options exist for development of a surface reflectance model – the GOES-R dense dark vegetation approach; MAIAC; and the GEO+LEO approach developed by CSIRO. There is also potential to develop approaches that combine the complementary characteristics of GEO and LEO satellites, such as sun and view geometry, and spatial and temporal resolution. The Australian experience with Landsat atmospheric correction may be of use in supporting algorithm development. Validation of an algorithm could be done against other satellite surface reflectance products, as well as in the vicinity of Australian aerosol ground stations. In another application,Himawari-8 thermal infrared bands have the potential to monitor surface particle size in desert regions, building on CSIRO work with ASTER.
- **Disaster Response and Management: Fires, Floods & Dust Storms (M. Thankappan, GA):**CSIRO, GA, BOM and DOD collaborated on the Sentinel Hotspots program in 2003, and GA has been running it operationally since 2005.Flood mapping is another area of interest for GA, and the temporal frequency of geostationary imagers may help to improve performance for this application by way of theincreasedpotential for data takes during breaks in the clouds. Himawari-8 will also help in the tracking and risk characterisation of dust storms (in conjunction with fractional cover information).
- **Land Surface Temperature (LST) and Surface Energy Balance (L. Renzullo, CSIRO):**Energy, Carbon, and Water Cycle science applications will be enhanced by Himawari-8 radiometric, spectral and temporal performance.Good agreement between MODIS Terra and Aqua LST, and Himawari-8 derived LST based on an initial assessment. There is good potential for ongoing work in this area, and a lot of good science that can be enabled by the information about energy distribution changes throughout the day.
- **Vegetation Processes and Carbon Cycle (P. Scarth, Univ. of Queensland):**Feedback from Australian users corresponds well with the application areas being discussed at this workshop. Accounting for changes in

BRDF is going to be key to employing Himawari-8 for time series analysis. In addition it is important to consider how the benefits of these new products will be delivered to society.

Oceans session

- **Ocean Product Development using Himawari-8 (H. Murakami, JAXA):**The Himawari-8 user group has a focus on ocean applications, which is looking at the adaptation of MODIS ocean algorithms. Sea Surface Temperature and Ocean Colour applications are the top priorities of interest.
- **Potential of Ocean Colour Observations from Geostationary Orbit: Application to Himawari-8 (D. Antoine, Curtin Univ.):**In many respects, polar orbiting instruments study the effects of processes, whereas geostationary instruments study the processes themselves. It is important to monitor the diurnal cycle to get the most comprehensive picture of ecosystem behaviour possible. The realisation of Ocean Colour products at geostationary observational frequency would likely result in the opening up of new opportunities with respect to model integration, despite the fact that Himawari-8 is not likely the ideal Ocean Colour sensor due to concerns around lowsignal-to-noise ratio (SNR). The Ocean Color Advanced Permanent Imager (OCAPI) mission being developed in Europe may be of interest to the group, though it is still under development.
- **Coastal Applications and IMOS Validation Support for Himawari-8 (T. Schroeder, CSIRO):** Several application areas have been identified, including: physical processes such as tides, monitoring and forecasting of flood plumes and algal blooms, and data assimilation into bio-geochemical models.To date, CSIRO has only evaluated some of the Himawari-8 sample data for Ocean Colour at Top-Of-Atmosphere (TOA) – broader assessment is required. Some scanner artefacts were visible in the imagery and require additional post-processing. There was a good comparison of Himawari-8 TOA data with simulations performed for MERIS. Several challenges for geo-stationary ocean colour observations were addressed – atmospheric correction at higher sun angles, signal to noise, sensor calibration and stability, options for cross calibration with Low Earth Orbiting satellites and computational needs for full archive re-processing. Continuous data from the Lucinda Jetty Coastal Observatory will be key to evaluate Himawari-8/9 ocean colour data in Australia.
- **Water Quality and River Plume Monitoring in the Great Barrier Reef: An Overview of Methods based on Ocean Colour Satellite Data (M. Devlin, James Cook Univ.):** Remote sensing provides important monitoring for the Great Barrier Reef, for example enabling observations of complex changes in water quality which are hard to evaluate based on *in situ* observations only.There is a need for greater resolution to resolve small-scale processes, and in particular plume imagery can be difficult to retrieve. The trade between temporal and spatial resolution is important – but decreased spatial resolution for increased temporal resolution is a good trade. As well, there may be a need to move from manual

classification to semi-automated classification in order to make best use of the temporal frequency.

– **Use of RemoteSensing Reflectance in Biogeochemical Data Assimilation (M. Baird, CSIRO):** Comparison between MODIS and Himawari-8 simulation Ocean Colour observations are encouraging, and suggest that there could be a comparable product from Himiwari-8 data.

Brief breakout session outcomes

Atmospheresession

– **Which are the key non-meteorological products that could be developed?** Aerosol and solar radiation. Lower priority for total column ozone and trace gases (SO2, CO2).

– **Who is already actively working on product/algorithm development?** Both Japanese universities and BOM have systems built around mature solar radiation algorithms and which continue from earlier GEOs.

– JMA is developing Himawari-8 yellow dust detection focusing on the region of Japan. CSIRO has developed a dual view approach to aerosol retrieval that it is applying to Himawari-8 combined with MODIS or VIIRS. U Queensland has begun a discussion with NASA on applying the MODIS Deep Blue algorithm to Himawari-8. BOM has begun a discussion with NASA on Himawari-8 application of the MAIAC algorithm, which simultaneously retrieves aerosol and surface reflectance and has been applied to MODIS, VIIRS and GOES-R.

– Japan (Chiba U) has applied its SGLI surface reflectance approach to Himawari-8.

– The BOM has begun a discussion with the University of Wisconsin on accessing the GOES-R code for Total Column Ozone once it is adapted to Himawari-8.

– **What are the main processing and algorithm challenges?** Over the land, the aerosol and surface reflectance signals are intimately coupled and so a joint self-consistent retrieval is preferred. Both the CSIRO and MAIAC approaches do this.

– Because retrievals over land from an advanced GEO are challenging and new, it is worthwhile supporting the development and evaluation of multiple algorithms before choosing an approach for operational use.

– **What data is needed for validation and inter-calibration with polar orbiting satellites?** The ground-based aerosol observation networks currently run by Japan (SkyNet) and in Australia (BOM and CSIRO) provide excellent validation data for Himawari-8 aerosol products. They also enable an approach to validation of surface reflectance whereby accurate atmospheric correction is possible for the vicinity of each aerosol station (NASA's ASRVN approach).

– Total column ozone can be validatedagainst data from polar orbiting satellites and ground-based ozone networks.

- **Who are future data end users?** Aerosol (including smoke) as an input to air quality monitoring and forecasting systems run in Australia by the BOM/CSIRO and by universities; the conversion to health-relevant aerosol parameters such as $PM_{2.5}$ and PM_{10} is important. Initialisation and validation of BOM smoke dispersion model. Assimilation of aerosol into atmospheric modelling systems such as SPRINTARS (Kyushu U) and possibly internationally such as the European MACC system. Validation of aerosol output from models such as MACC (needed by BOM). Dust aerosol monitoring is a high priority in east Asia and Japan, and in Australia the NSW Department of Environment and Heritage would use it for air quality and as an indicator of land condition. The JAXA supported SAFE project has an interest in air pollution.
- Geoscience Australia would use an operational stream of BRDF model coefficients resulting from joint aerosol and surface reflectance retrieval, and potentially the aerosol product, in their Landsat processing.
- Total column ozone at subdaily time resolution is of interest for air quality (troposphere, urban, e.g. U Melbourne) and stratospheric dynamics (specific users to be identified).
- **Are there synergies with the other thematic groups – product dependencies?** Land surface reflectance and aerosol retrieval are best done together.
- Possible overlap of land and ocean activity in aerosol retrieval and atmospheric correction.
- Specification of solar radiation products to meet land community requirements.
- **What are the opportunities for funding or collaboration?** GA, BOM and CSIRO have a common interest in joint retrieval of aerosol and surface reflectance.
- Japan and Australian partners could exchange validation data from ground networks (aerosol, solar radiation), exchange documentation on validation protocols, and compare algorithm performance.
- Funding opportunities on the Australian side include: Federal and state government programs; ARC Linkage scheme for Australia-Japan collaboration; NMHRC; National Emergency Management Projects; Proposed ARC Centre for Excellence for air quality.
- **Other points**
- Discussion focussed on products over land.
- The region of Japan's aerosol products will not necessarily cover Australia.
- Himawari-8 products might potentially be most useful to users indirectly as inputs to modelling systems or blending with products from other satellites.
- Trace gases SO2 and CO2 were discussed briefly. There is some low priority interest but it is not clear what advantages Himawari-8 offers over LEOs.
- **Follow-up Actions Were Agreed for Atmosphere:**

1. Atmosphere group to develop a short document that for joint aerosol and surface reflectance retrieval: identifies users and their requirements; gives product specifications; lists partners in development; lists algorithm options; outlines the path to operations; identifies potential funding sources.
2. Australia and Japan exchange documentation on validation networks and protocols.

Land Breakout Session Outcomes

– Luigi Renzullo (CSIRO) Chaired the discussion and asked what products we wanted for Land applications from H-8:
  - Surface Reflectance products with geometric correction
  - Cloud mask information
  - Pixel quality metrics
  - Further data may be needed for effective BRDF corrections
  - Assume that techniques should be applicable to the full disc of data from H-8
  - Land surface Temperature will be one derived product
– Luigi asked Koji Kajawara about the Short Wave Radiation products discussed in the Japanese presentations yesterday – the hope is that these will be shared;
– Stephen Ward noted Alex Held's original suggested products and hoped we could verify these as the targets for the cooperation:
  - Dynamic tracking of Fire spread and associated modeling
  - Land-Surface Temperature and evapotranspiration
  - Monitoring of rapid changes and land-surface dynamics, associated with: Rainfall events, Drying/Droughts, Fires & Burnt Area Mapping, Flood Response, Cyclone Damage, Crop Phenology dynamics, Aerosol Climatology.
– **Fire and burnt area:** Medhavy (GA) noted there are algorithms based on the ABI instrument which should work after testing; GA has a project to integrate into Sentinel; APRSAF Sentinel Asia also has a Fire WG looking at similar capabilities; Japanese fire counterpart could be Dr Moriyama of Nagasaki University; Burnt area is not yet a standard product in GA although there are capabilities and candidates; fire detection is the primary operational interest; for burnt area weeks/month would be sufficient temporal resolution;
– **Land-surface temperature and evapotranspiration:** Luigi can be the Australian point of contact – we need to identify a Japanese contact; there are many candidate evapotranspiration algorithms (BOM is doing some work here). Australia has done some model inter-comparison work. GCOM-C Project Team and JMA WG for H-8 would be the most likely source of a counterpart for this kind of work – possibly Dr Moriyama again; ET model inter-comparison is a possible

area for cooperation and is a strong focus in Australia; Tim McVicar (CSIRO) will be POC for ET issues;

- **The other applications were seen as coming out of the basic SR product as the enabling product:** Ian Grant (BOM), Fuqin Li (GA), Peter Scarth (UQ) likely to be involved in the core SR work.
- **Flood mapping:** real-time flood warning from H-8 is a real opportunity – combining the precipitation estimation and the water extent mapping; a 1km pixel may be too coarse for most purposes. Cate Ticehurst (CSIRO) & Norman Mueller (GA) would be the contacts on Australian side. ICHARM is in charge of international flood response within Japan and may be the counterpart; there are several groups including those using microwave data;
- **Vegetation:** GA has dynamic land cover capabilities; suggested that a single daily observation is sufficient; H-8 repeat imaging may offer more opportunities for daily coverage of each pixel;
- **Aerosol Optical Depth:** this could be considered to be a land product also and is an important product in its own right; atmosphere breakout group likely to address.
- In terms of the main processing challenges, timeliness was seen as key. Some discussion around access to NCI.
- What data is needed for validation and inter-calibration with polar orbiting satellites? Discussed linkage to GCOM-C activities. Product comparison and sharing cal-val info with other LEO missions will be needed.

Luigi suggested establishing a mailing list for the Land group for the Japan-Australia cooperation. Matt Paget suggested establishing a website to improve communications also.

- **Who are future data end users?** TBA.
- **Are there synergies with the other thematic groups – product dependencies?** TBA.
- **What level of resources is needed to achieve product/algorithm development?** TBA.
- **What are the opportunities for funding or collaboration?** TBA.
- **Do we and if so - how do we want to engage as a group/community in future?** TBA.

Oceans Breakout Session Outcomes

- Focuses for application areas of the group are Ocean Colour and Sea Surface Temperature (SST). The group tried to identify the gaps in existing capability, and then discussed the issue of funding and resources. Currently funding for the development of new products is a significant issue.

- It was agreed that Himawari-8 will likely not replicate the Ocean Colour performance of MODIS. It will provide more frequent but perhaps less accurate products that can be inter-calibrated with polar-orbiting sensors such as MODIS.
- **Which are the key non-meteorological products that could be developed?** The key product areas are Ocean Colour and SST.
    - **SST:**
        - Current SST algorithms need adaptation for Himawari, but the spatial and temporal coverage by AHI will be much better in comparison to current sensors. Cal/Val is still being done using drifting buoys.
        - SST may not be the most critical product, as it is very well managed in comparison to ocean color, which is a lot more exploratory.
        - SST is not more advanced than ocean color, but algorithms are easily transferrable and its transfer across to AHI should be seamless.
    - **Ocean color:**
        - Accurate atmospheric correction (AC) is a pre-requisite for water quality retrieval such as Total Suspended Solids (TSS) or chlorophyll-a (CHL-a). The importance of AC especially over coastal waters was discussed. Information about the spatial distribution of TSS from river discharge is required to improve environmental risk assessment and management. True colour images may provide qualitative information on flood plume extents. CHL-a as a proxy for phytoplankton biomass and primary productivity would be more difficult to derive given the spectral limitation of Himawari-8/9.
            - Future cal/val exercises for AHI will need high quality in situ data both in Japan and Australia. In Australia, there is at present only the Lucinda Jetty Coastal Observatory and the IMOS bio-optical data base that can offer an ideal facility for providing high quality in situ datasets.
            - Therefore renewed and concerted support for extended funding for the Lucinda Jetty Coastal Observatory is necessary.
    - **Additional products are required as input for atmospheric correction and ocean colour inversion:**
        - **Cloud masking**
        - **Total ozone mapping**
        - **Surface wind speed** and
        - **Surface pressure**.
- **Who is already actively working on product/algorithm development?** The BOM is working on an SST product. Current SST observations are sourced from AVHRR (over MODIS), but it appears that Himawari-8 will add significantly to BOM SST products. This SST product is generated in the context of GHRSST. Japan is also involved in GHRSST, and has been working on its own new SST

algorithm, which it plans to contribute. CSIRO is working on ocean colour inversion incl. atmospheric correction.

- **What are the main processing and algorithm challenges?** Getting a good surface reflectance product requires a good atmospheric correction especially for coastal waters. Collaboration with the Himawari-8 team on AC over ocean would be a useful step. Information on atmospheric correction techniques may also be useful for the land and atmosphere groups.
- There is a funding opportunity at the BOM (Two years of funding) which could help to address some of these issues.
- **What data is needed for validation and inter-calibration with polar orbiting satellites?** IMOS bio-optical data base as well as data from the Lucinda Jetty Coastal Observatory provide validation data for the Australian region.
- **Who are future data end users?** Too early to conclude as data quality is still unknown. Potential end userd could include:
    - Great Barrier Reef Marine Park Authority (GBRMPA) that uses remote sensing products to **reporting on changing water quality**,
    - eReef dashboard users such as the Department of the Environment (e.g., **testing hypothesis of Crown of Thorns outbreaks**),
    - James Cook University (JCU) for e.g., ecosystem health understanding and river outflows.
- **Are there synergies with the other thematic groups – product dependencies?** Perhaps around refining atmospheric correction. Cloud masking algorithms. Ozone surface pressure products required for atmospheric correction over ocean.
- **What are the opportunities for funding or collaboration?**Thomas circulated a proposal call by the Australian Academy of Science for short-term research visits to Japan in 2016-2017.**Several Follow-up Actions Were Agreed for Oceans:**

3. **BOM to circulate a list of products that are currently available** or will be available via the agency, and how they can be accessed by the various agencies / users. Coordinators: G Stuart; Leon M
4. **Atmospheric correction** - coordination activity to develop and validate atmospheric correction product over ocean/coastal. CSIRO has a PhD student working on atmospheric correction and in-water retrieval for water quality.
5. List of **desirable key products** (ocean colour and SST) to be developed over time associated with a priority ranking, thus providing the group with working plan and directions.
6. **Test dataset** – accessing a set of images covering a few days as a test dataset. Coordinator: Thomas to follow-up with BOM on how to access this dataset.
7. **Making IMOS bio-optical data base available to JAXA**. Coordinator: Thomas to follow this up with JAXA.

Workshop wrap-upDiscussion

- It was agreed that a list of priority products should be compiled, and **ACTION** for Thomas to initiate the process with a draft circulated for comment and iteration.
- The BOM is working on a cloud mask product for H-8 which could be of interest to the Ocean Colour community.
- Leon noted that there is a bit of an information gap / no forum to disseminate information about data availability, but expect to resolve soon. It was agreed that website would be valuable as a communication channel for the community forming around the H-8 applications.
- Thomas askedwhether a follow-up workshop once a year could be useful and participants confirmed the value of the workshop and hoped to repeat it. In response to a question about coordination capacity, Stephen Ward noted that his team were sponsored by JAXA to support the coordination efforts in the GEO-LEO area and, subject to agreement with his JAXA colleagues, he should be able to initiate some fundamental organizational activities to consolidate the workshop, confirm structures and establish participants, and get communication going. These can include: agreeing a URL and establishing a web-site (initially for the bilateral efforts); posting the workshop materials; confirming the Leads on each side for the 3 teams; gathering contact details for all participants in each Team and each algorithm collaboration; setting up mailing lists for work-specific dialogue and for general updates on data availability etc. Stephen noted the importance of getting specific work progressed at the technical level and managing expectations broadly around the schedule etc.
- Thomas thanked all attendees for their time and effort in coming to the workshop and looked forward to the exciting opportunities offered by the proposed collaboration.

Annex: Draft table of contacts for the thematic teams and product development efforts

Land		
	Japan	**Australia**
Coordinators	**Koji Kajiwara (Chiba U.)**	**Luigi Renzullo (CSIRO)**
Surface Reflectance	Koji Kajiwara/Yoshiaki Honda ?	Ian Grant (BOM)
Fire & Burnt Area	Masao Moriyama (U. Nagasaki)	MedhavyThankappan (GA)
Land Surface Temperature	Masao Moriyama ? (U. Nagasaki)	Luigi Renzullo (CSIRO)
Evapotranspiration	TBA	Tim McVicar (CSIRO)
Vegetation	TBA	GA ?
Flood Mapping	TBA	Cate Ticehurst (CSIRO) Norman Mueller (GA)
Ocean		
Coordinators	**Hiroshi Murakami (JAXA)**	**Thomas Schroeder (CSIRO)**
SST	TBA	Leon Majewski (BOM)
Ocean Colour	Hiroshi Murakami (JAXA)	David Antoine (Curtin U.), Thomas Schroeder (CSIRO)
Atmosphere		
Coordinators	**Takashi Nakajima (Tokai U.)**	**Ian Grant (BOM)**
Aerosol	TBA	Ian Grant

Annex: Workshop attendance list (alphabetical by surname)

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