New Observations & Use Of Models For Designing And Prioritizing (Satellite) Observing Systems

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DISCUSSION TOPICS

i. New/coming observations within 5 years. Are we positioned to take advantage of?

ii. Gaps in observations, what is needed for model development/ evaluation?

iii. How can the modeling community help with prioritizing and defining new obsevations?

I. New Observations (< 2022) Relevant to Model Development and Evaluation

(non-exhaustive list)

Major programs include
ESA
- Living Planet Program/Explorer
- Copernicus/SentineL

NASA
- Decadal Survey
- Earth Venture (Mission, Instrument)

ISRO, CNES, JAXA, DLR, CNSA, etc
Operational – EUMETSAT, NOAA, IMD, JMA, CMA

5 Year Horizon - Mostly Relevant to Weather/Climate Model Support						
KARI	**JAXA**	**ISRO/NASA**	**CNES/NASA**	**GFZ/NASA**	**ESA**	**NASA**
GEMS - O3, NO2, aerosol	GCOM-C - multi-spectral VisIR	NISAR - biomass and ice sheets	SWOT - mesoscale ocean topography & lake/river heights	GRACE-FO - gravity, ice-sheet, groundwater, ocean mass storage	EarthCARE - cloud radar w/ doppler	SWOT - mesoscale ocean topography & lake/river heights
ABI - IR Sounder (e.g. GOES-R, MTG)	EarthCARE - cloud radar w/ doppler				ADM-Aeolus - Winds	GRACE-FO - gravity, ice-sheet, groundwater, ocean mass/heat storage
	GOSAT-2 - CO2, CO, CH4				Biomass - biomass	NISAR - biomass and ice sheets
					Sentinel 4 - O3, NO2, aerosol	IceSat-2 - glaciers, ice-sheet
					Sentinel 5 - O3, NO2, aerosol	OCO-3 - CO2, SIF
	Composition				Sentinel 6 - Sea Level	ECOSTRESS - evapotranspiration
	Carbon & Ecosystems		**Geostationary**			GEDI - forest/vegetation structure
	Water w/ SMAP, SMOS, ECOSTRESS					TEMPO - O3, NO2, aerosol
	Atmosphere Physics w/GOES-R & MTG		**ISS**			MAIA - aersol type & size
						GeoCARB - CO2, CO, CH4

ii. Gaps in observations, needs for model development/evaluation?

REQUIRE

- Continuation of existing backbone framework developed for weather: satellite and conventional observations
- Continuity of satellite observations for climate (beyond above):
  - altimetry/sea-level (Topex/Jason/Sentinel-6),
  - GRACE/GRACE-FO,
  - Possible OCO-2/3 (CO_2, SIF)

GAPS:

- Boundary layer (winds, thermodynamics, composition)
- 3D winds (esp tropics and BL)
- Snow water equivalent
- Sea ice thickness
- Surface and root zone soil moisture
- Near surface air quality/composition
- In-cloud water vapor, temperature, vertical motion
- Aerosol, cloud, precipitation spectrum/processes (liquid vs ice)
- Ocean winds, waves and currents
- What else? What are highest priorities? Surface fluxes…
- State of operational ocean observations precarious (except SST, SSH…) i.e. scatterometer winds, heatfluxes, salinity
- More Investment in free, NRT data access for research satellite missions for exploring data assimilation uses

III. How to identify, prioritize and design future observing systems to meet needs of the modeling community and address critical/complex science questions?

- The era of Earth Science "discovery" missions (put it up and it will be useful) is over.
- The totality of new science and continuity missions requires an international fleet of complementary and synergistic contributions, with partnerships becoming more common.
- Trade space for (space-based) earth observation systems exploding:
  - ✓ Earth system components (land, ocean, biosphere, composition, cryo, atmos,etc)
  - ✓ Continuity of old measurements vs new science / research missions
  - ✓ Platforms: Cubesats, small-sats, … conventional large-class.
  - ✓ Constellation approaches (e.g. A-Train, CYGNSS)
  - ✓ Tight formation flying for rapid changes (e.g. Δt = minutes)
  - ✓ International space station -> future science space station
  - ✓ GEO, LEO, low-latitude … passive/active...
  - ✓ Total $ ~fixed but huge O($B)/yr across agencies/countries aside from op weather
- Modeling/OSSE tools are sorely needed across climate and other Earth Science areas (along w/ weather) across a range of complexity (e.g. simple sampling, hypothesis testing, forecast/projection OSSEs) to identify, prioritize & design new observing systems.
  - ✓ Ability to incorporate new/experimental forward operators into models/simulations
  - ✓ Truth simulations – sufficient output, high temporal resolution (~minutes)
  - ✓ Accounting for model uncertainty (e.g. physical ensembles)

<u>The space agencies alone don't own/manage all the modeling expertise and resources to optimally address next generation needs – closer partnership with and direction from the modeling community is needed. How will new WCRP organization address this?</u>

Recommendations

Taking advantage of upcoming new satellite systems –

Early engagement by WGs in satellite mission product and GCM compatible forward operator algorithms/code.

Assessing use and value of currently available satellite and other in-situ networks of data –

Aggregate WCRP/WWRP WG report on the use and value of the currently available set of satellite and other observations. Maybe based on needs/value assessment and/or workshop on use and value in addressing WCRP/WWRP needs.

- For which variables is continuity needed or most important?
- What are the most critical remaining observational gaps

New observations

WCRP/WWRP can have a significant impact on what new missions get developed, but the identification and prioritization of needs to be more specific and quantitative. This is an independent consideration beyond the operational weather satellite systems.