Roles of aircraft in the OASIS Vision

Mark A. Bourassa on behalf of Meghan Cronin and the OASIS team

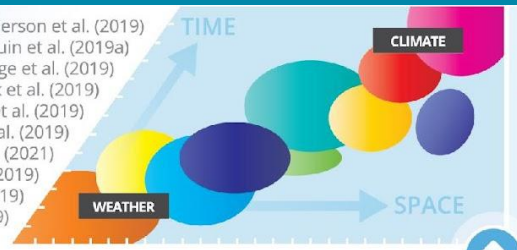
OASIS

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Observing Air-Sea Interactions Strategy (OASIS) is harmonizing community recommendations from OceanObs'19 and UN Decade Laboratories...

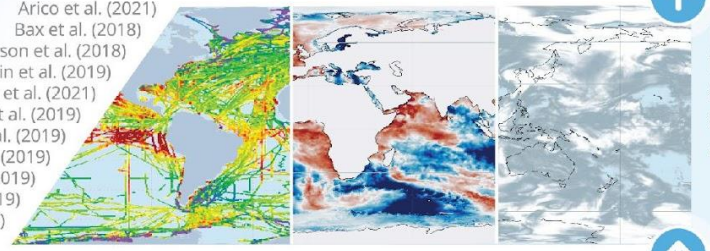
...into three Grand Ideas

Anderson et al. (2019)
Ardhuin et al. (2019a)
Bange et al. (2019)
Bax et al. (2019)
Canonico et al. (2019)
Domingues et al. (2019)
Estes et al. (2021)
Penny et al. (2019)
Pinardi et al. (2019)
Powers et al. (2019)



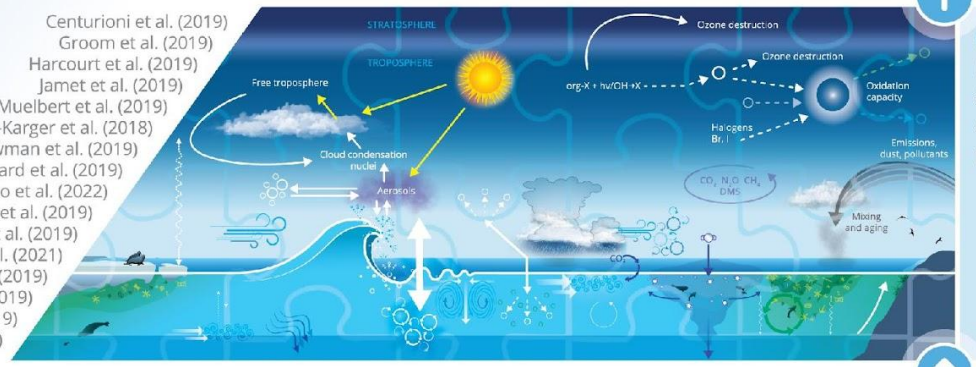
Improved Earth system *(including ecosystem)* forecasts for a predicted, clean, accessible, healthy, safe & productive ocean

Arico et al. (2021)
Bax et al. (2018)
Benson et al. (2018)
Cronin et al. (2019)
Cronin et al. (2021)
Fennel et al. (2019)
Foltz et al. (2019)
Hermes et al. (2019)
Maximenko et al. (2019)
Smith et al. (2019)
Speich et al. (2019)
Wanninkhof et al. (2019)



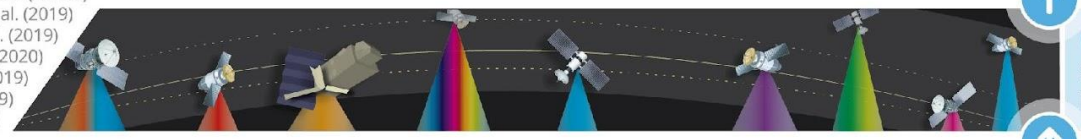
Improved ocean information serving stakeholders around the world

Centurioni et al. (2019)
Groom et al. (2019)
Harcourt et al. (2019)
Jamet et al. (2019)
Muelbert et al. (2019)
Muller-Karger et al. (2018)
Newman et al. (2019)
Lombard et al. (2019)
Marandino et al. (2022)
Kent et al. (2019)
O'Carroll et al. (2019)
Sequeira et al. (2021)
Steinhoff et al. (2019)
Subramanian et al. (2019)
Swart et al. (2019)
Villas Bôas et al. (2019)



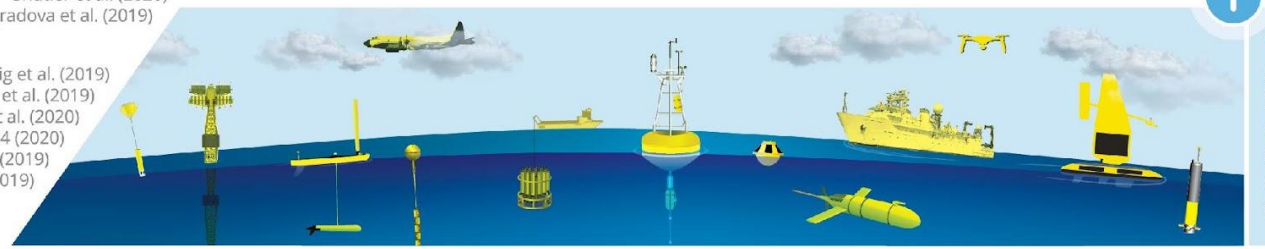
Grand Idea #3
Improved models & understanding of air-sea interaction processes

Ardhuin et al. (2019b)
Bourassa et al. (2019)
Ciani et al. (2019)
Gentemann et al. (2020)
Gommenginger et al. (2019)
Morrow et al. (2019)
Rodríguez et al. (2019)
Shutler et al. (2020)
Vinogradova et al. (2019)



Grand Idea #2
Satellites optimized for air-sea fluxes

Meinig et al. (2019)
Pearlman et al. (2019)
Sabine et al. (2020)
SCOR Working Group 154 (2020)
Smith et al. (2019)
Wang et al. (2019)



Grand Idea #1
A globally distributed in situ air-sea observing network built around an expanded array of time series stations

Image: Sarah Battle/NOAA visit: airseaobs.org

From: Cronin et al. (2022) "Developing an Observing Air-Sea Interactions Strategy (OASIS) for the global oceans"

Grand Idea #1: A globally distributed network of mobile air-sea interaction observing platforms built around an expanded array of Timeseries Stations

How can we increase **profiling** of the **lower Atmospheric Boundary Layer** over the ocean?

?

How to build an emerging network of **Uncrewed Surface Vehicles?**

?

What is optimal **network** design for the **Tropical Pacific Observing System**?
What is optimal **network** design for **Small Island Developing States**?

?

Grand Idea #1: A globally distributed network of mobile air-sea interaction observing platforms built around an expanded array of Timeseries Stations

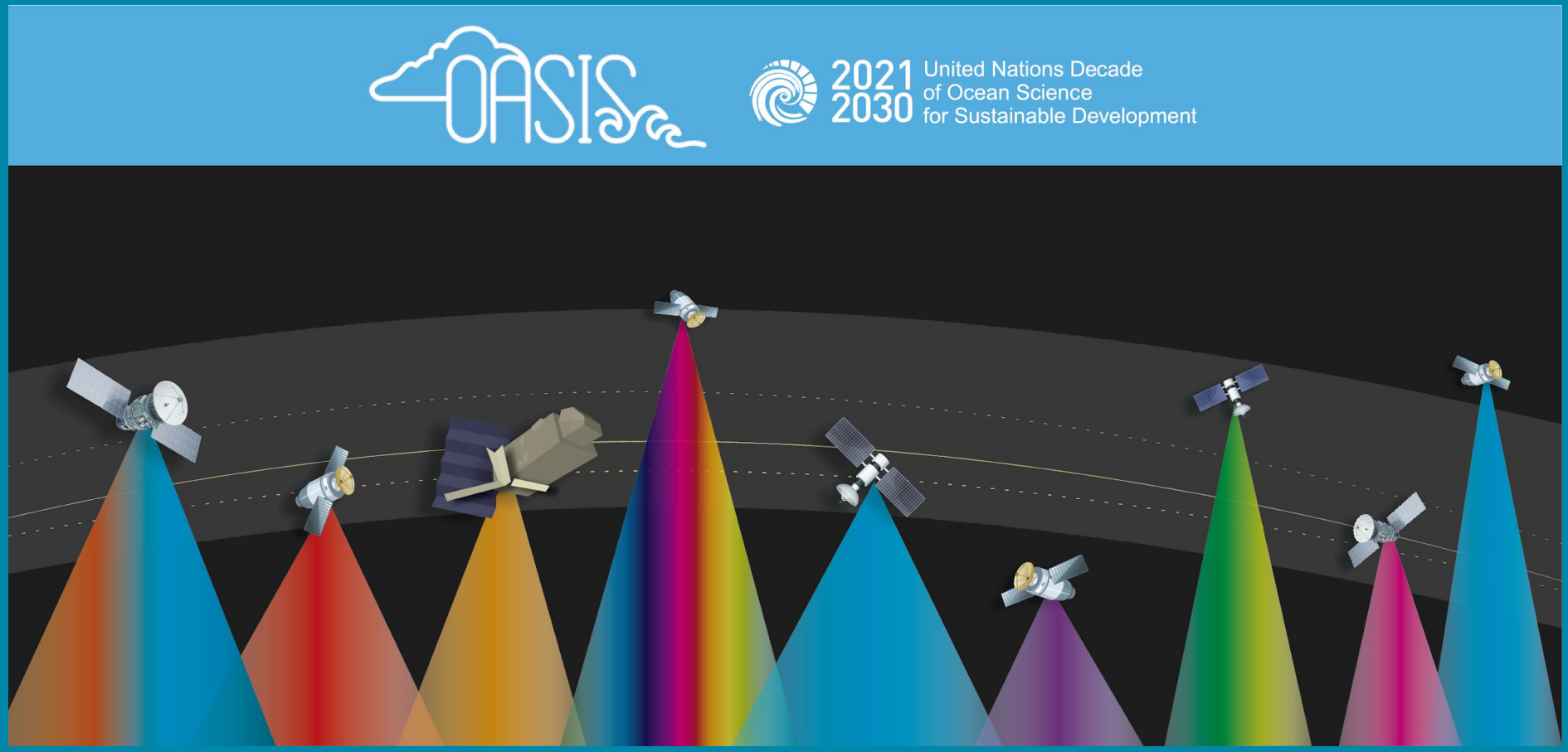
Roles of Crewed Aircraft:

- Delivery of in situ platforms to isolated locations
- Extreme events
  - Targeted delivery of in situ platforms (e.g., buoys, dropsondes)
  - Aircraft based instruments (radars, lidars, aerosols,….)
- UAVs
  - Measurements in areas of strong atmospheric or oceanographic gradients
  - Uncrewed vehicles could sample around a ‘mothership’ platform
  - Ideal for high vertical resolution profiles of wind, temperature and humidity, as well as determining atmospheric boundary-layer heights

Grand Idea #2: Satellites optimized for observing air-sea fluxes and interactions

How can we **profile** the Atmospheric Boundary Layer and capture **surface atmospheric conditions**?

?



How can we improve accuracy of **space-based air-sea fluxes?**

?

Surface currents from space would help provide a Safe Ocean & Clean Ocean in SIDS & Global South

Air-sea fluxes are direct communication between ocean and atmosphere

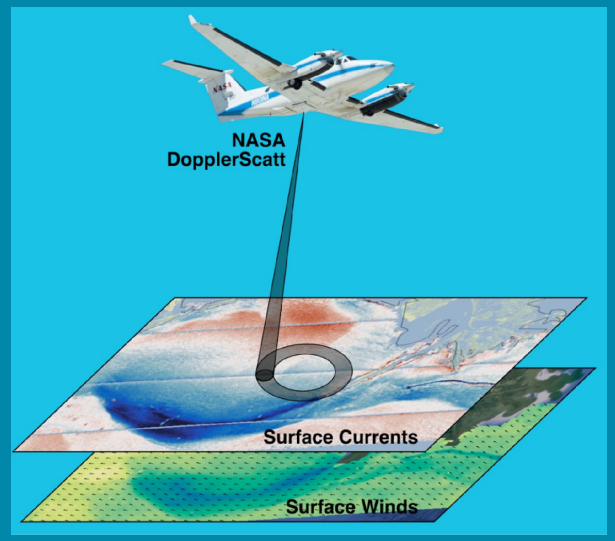
Grand Idea #2: Satellites optimized for observing air-sea fluxes and interactions

Roles of Crewed Aircraft:

- Platforms for developing and testing instruments – an incubator program for satellite instruments.
- The same instruments can be used for some aspects of calibration validation for the satellite instruments.
  - Examples: Dopplerscatt (for the ODYSEA mission), Lidars, atmospheric profilers
  - Routine validation will likely be cost-prohibitive unless the instruments can be based on a UAV
- Improved calibration and applications
  - Satellite-derived variables are usually sensitive to more variables than then measure. Aircraft-based observations can provide these missing observations, and thereby improve the calibration of the satellite-based variables.

As for the GPS sensors over the ocean, it would be extremely helpful to get moisture data over the ocean.. The GPS data over the ocean would give us precious data and could potentially bring a breakthrough." Takemasa Miyoshi (RIKEN, JAPAN)

Aircraft data could be a great source of validation data



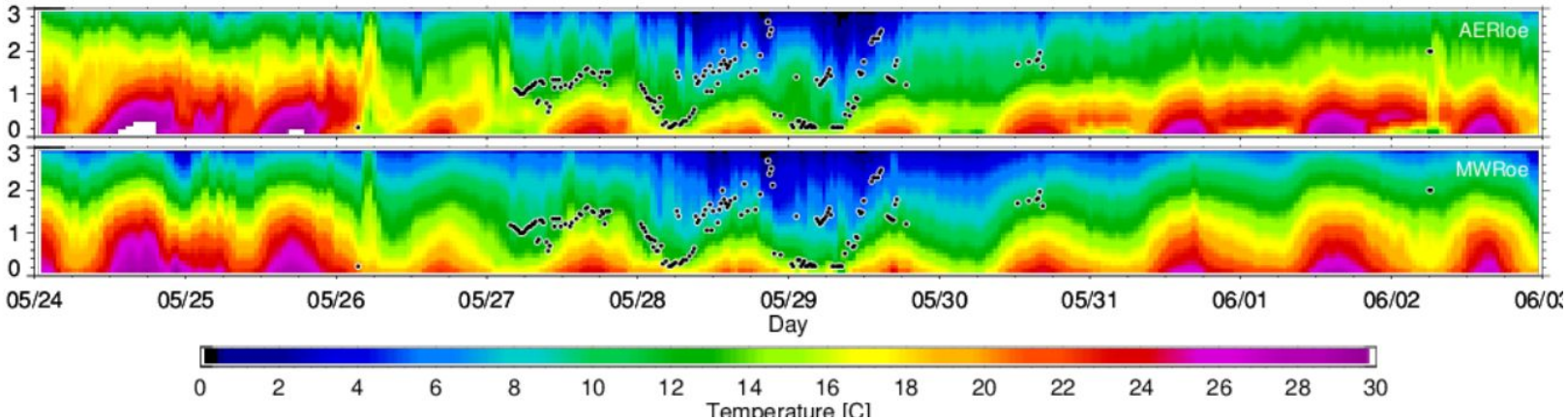
Rodriguez et al., *Remote Sens.* **2020**, *12*(15), 2388; **https://doi.org/10.3390/rs12152388**

Atmospheric emitted radiance interferometer (**AERI**)

Grand Idea #3: Improved models and understanding of air-sea interactions

Atmospheric emitted radiance
nterferometer (**AERI**)

Multi-channel Microwave
Radiometer (T, q)



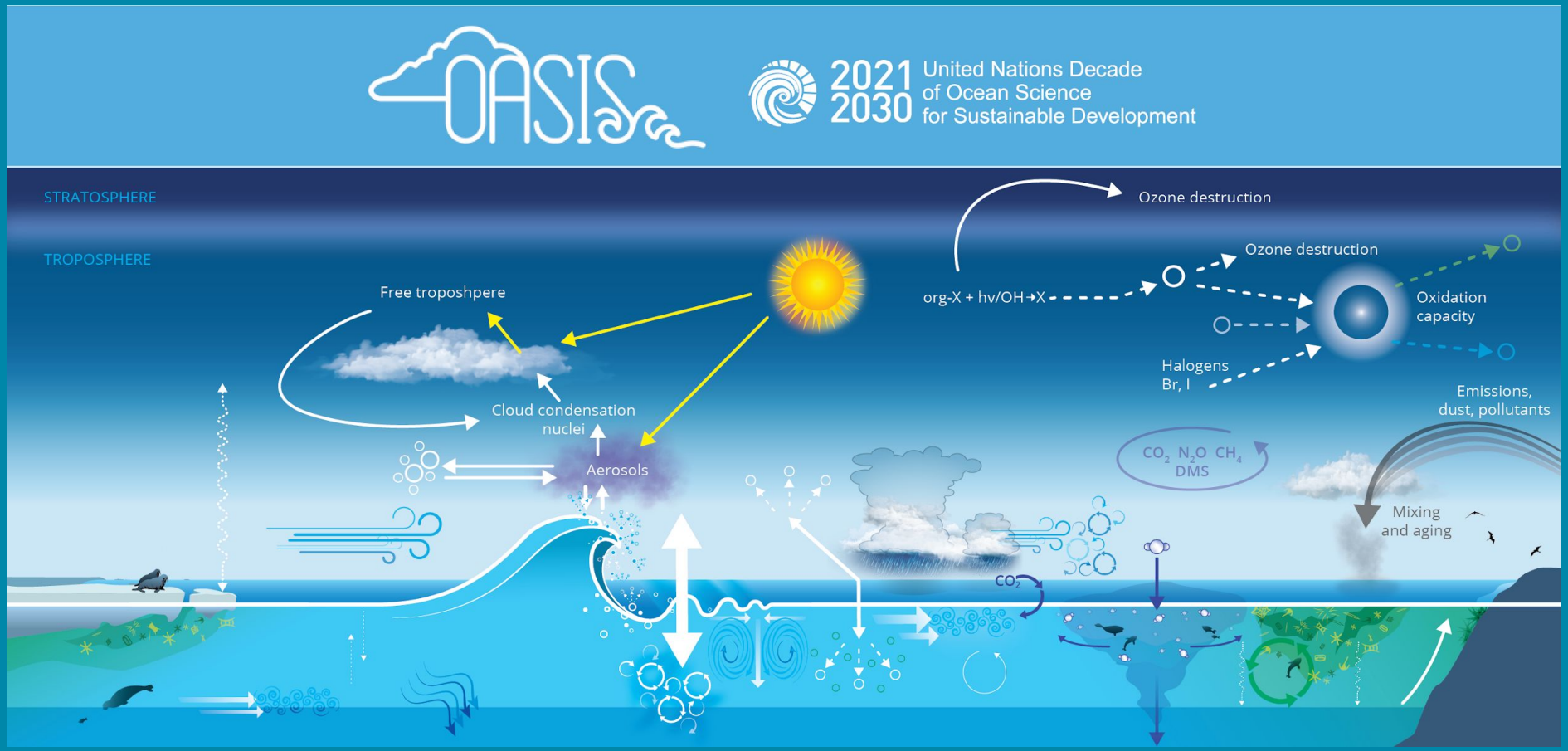
While diurnal variability is obvious in the temperature profiles from both instruments, we appear to see non-negligible differences between instruments and a lot of high frequency variability that might be associated with changing environmental conditions while the ship is moving.

This suggests that aircraft observations might capture this variability and be useful for calibration and science

Grand Idea #3: Improved models and understanding of air-sea interactions

What are key processes that couple the atmosphere and ocean?

?



How to improve understanding and forecasts of **ecosystem** response to stressors?

?

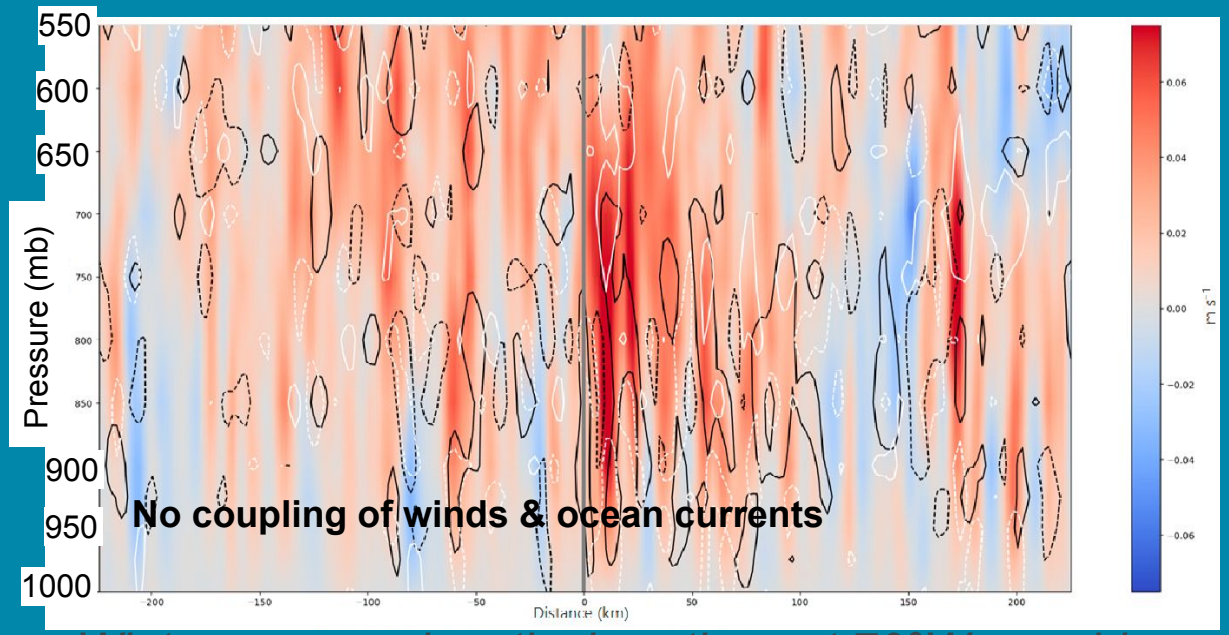
A hierarchy of Earth System models, including ecosystem forecasts, depend upon improved representation of air-sea interaction

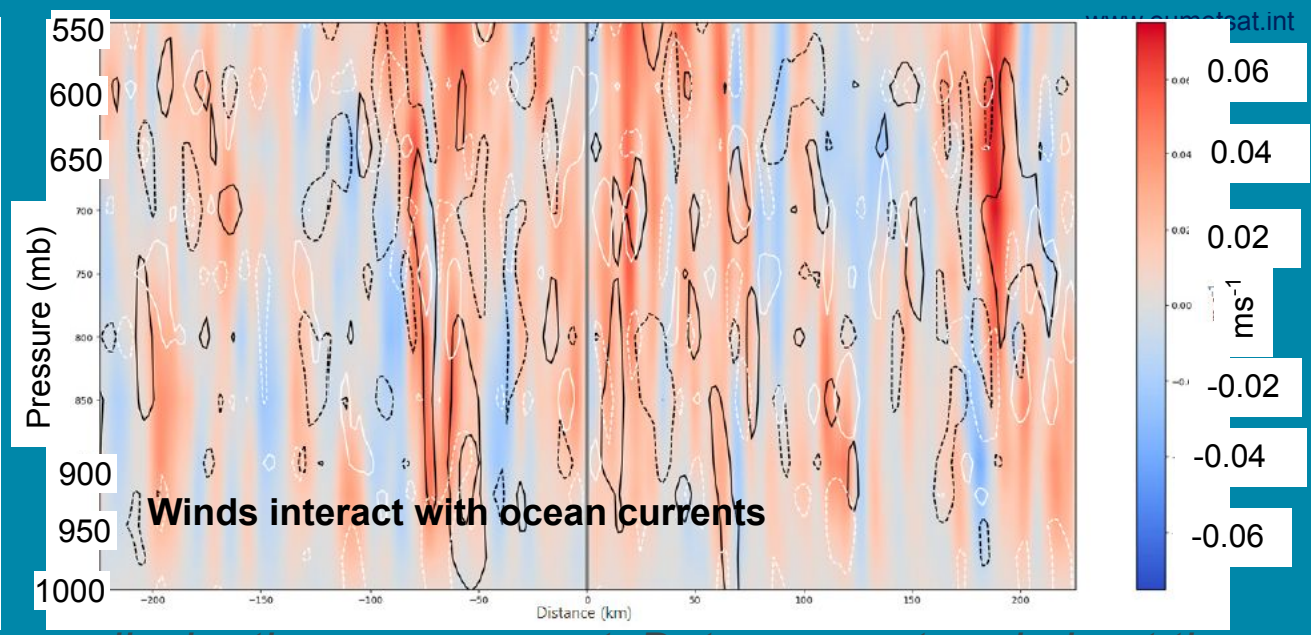
Grand Idea #3: Improved models and understanding of air-sea interactions (p1)

Aircraft-based observations are expected to be very important!

- Very high spatial resolution observations can provide new and likely necessary observations processes related to high resolution gradients in the atmosphere and the ocean
  - Example #1 gradients in air temperature influence horizontal winds and pressure gradients, which can impact vertical motion.
  - Example #2 gradients of ocean currents (e.g., curl) cause curl and divergence of winds in the boundary-layer, impacting vertical motion and boundary-layer height
  - Example #3 current gradients (curls) impact the curl of wind stress and Ekman-related vertical motion in the ocean. This motion can transport gasses to and from the deeper ocean.

Grand Idea #3: Improved models and understanding of air-sea interactions (p2)





Winter-averaged vertical sections at 70°W, roughly perpendicular the mean current. Data are centered about the strongest surface current (vertical line at distance = 0). The data from 00:00 UTC averaging over December, January and February.

Two-way coupled Ocean-Atmosphere (and in some cases wave) models show that ocean current gradient cause an Ekman (or Ekman-like) response in the atmospheric boundary. In some cases (we believe with atmospheric fronts) these model impacts extend into the free atmosphere!

Similar processes have been suggested for SST gradients.
Results are sensitive to model physics. We need boundary-layer atmospheric observations to improve the models.

May, J.C., and M. A. Bourassa, 2023: Atmospheric dynamic response to coupling currents to wind stress over the Gulf Stream. Atmosphere, 14(8), DOI: 10.3390/atmos14081216

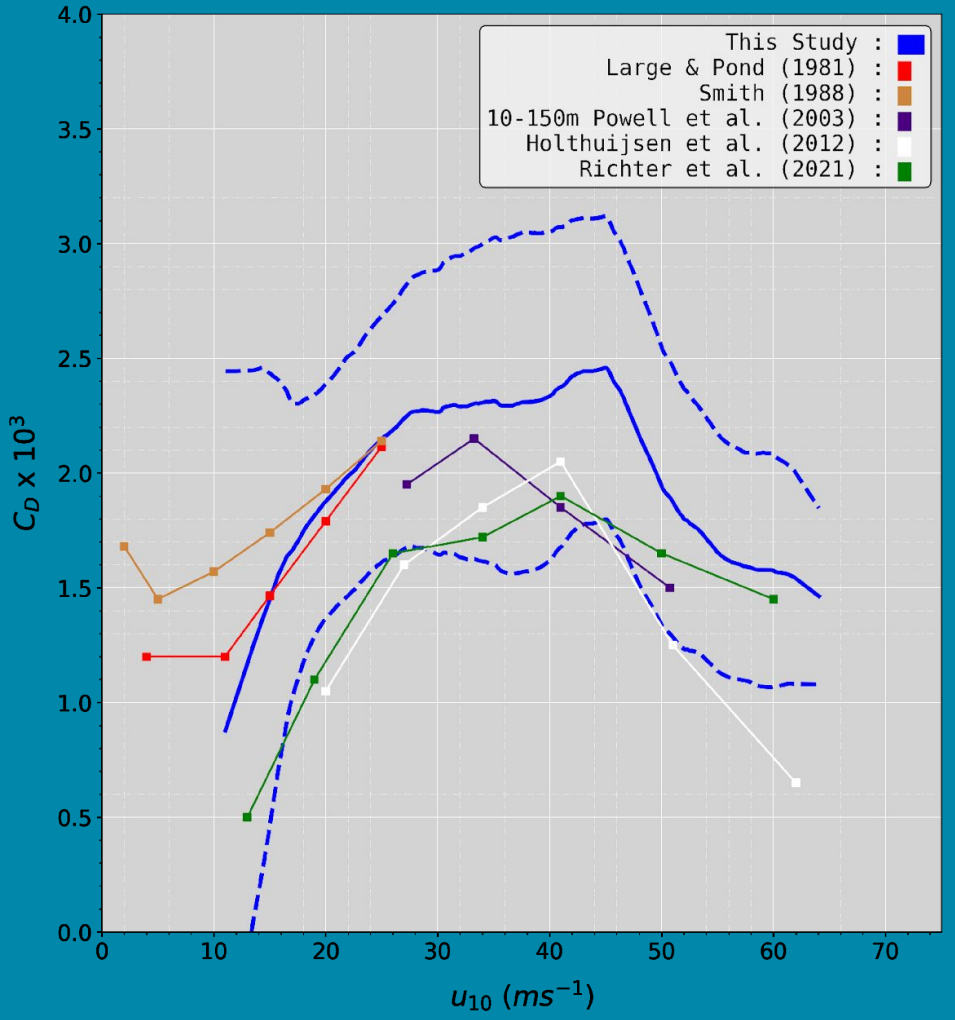
Grand Idea #3: Improved models and understanding of air-sea interactions (p2)

- Aircraft-based observations provide insights into air-sea interaction in tropical cyclones, where traditional satellite and in situ observations are problematic.
  - Example #1: high resolution surface winds that see through rain (e.g., SFMR*, IWRAP)
  - Example #2: dropsondes can be used to estimate surface turbulent fluxes.
  - Example #3: new UAVs should improve these capabilities and add to them

➢ $$C_D(10m) = \left(\frac{u_*}{u_{10} - u_{sfc}}\right)^2$$

➢ Used in parameterizations of stress and drag

➢ A roll-off at very high wind speeds (TC environment) has been shown in past studies, but the extent of the roll-off is hotly debated



Graphic from Wallace et al.'s 'Log-Profile Analysis of the Near-Surface Layer and Air-Sea Turbulent Fluxes in Hurricanes Using Dropsondes' (in preparation).

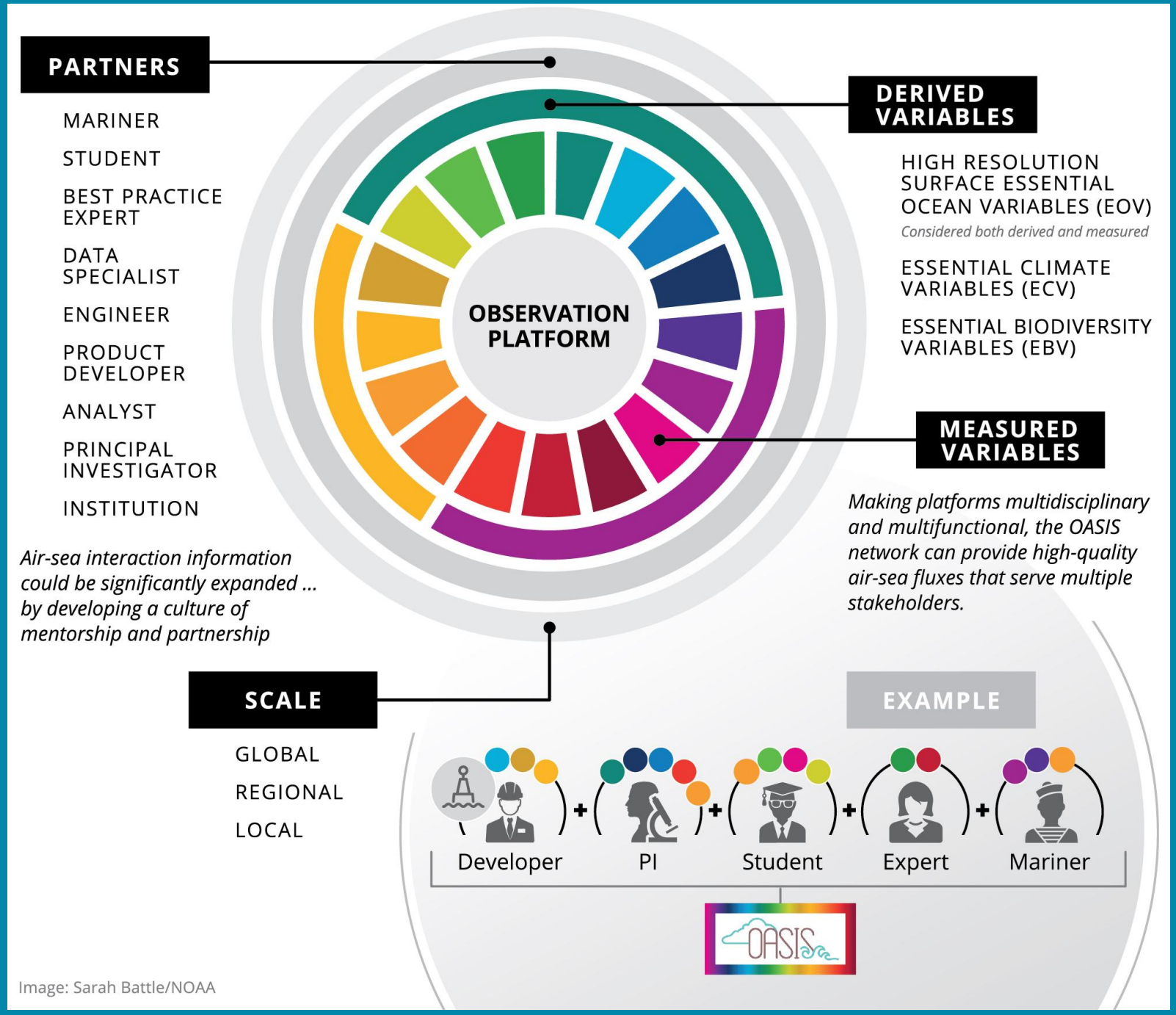


Image: Sarah Battle/NOAA

Observing Air-Sea Interactions Strategy (OASIS) **Theory of Change**

Air-sea interaction information could be significantly expanded by developing a culture of mentorship and partnership

Observations made globally, and used globally

To join Theme Teams, select "Get Involved" button on airseaobs.org
https://airseaobs.org/get-involved

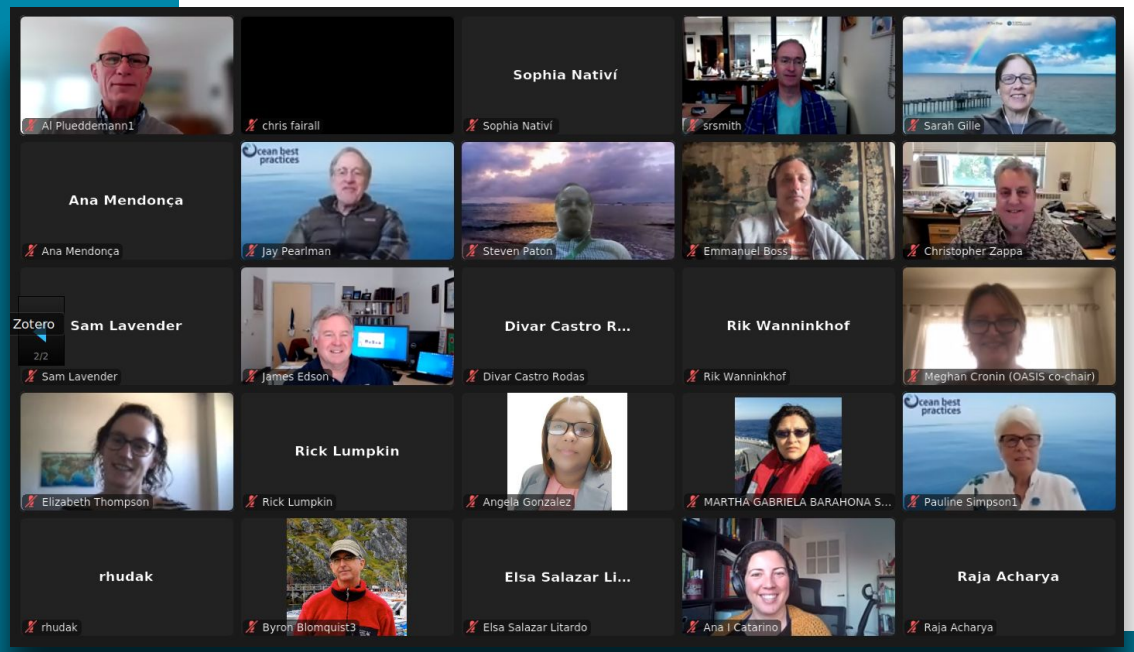
OASIS Co-Chairs & Staff

SCOR Working Group #162

OASIS Community

OASIS Theme Team (TT)

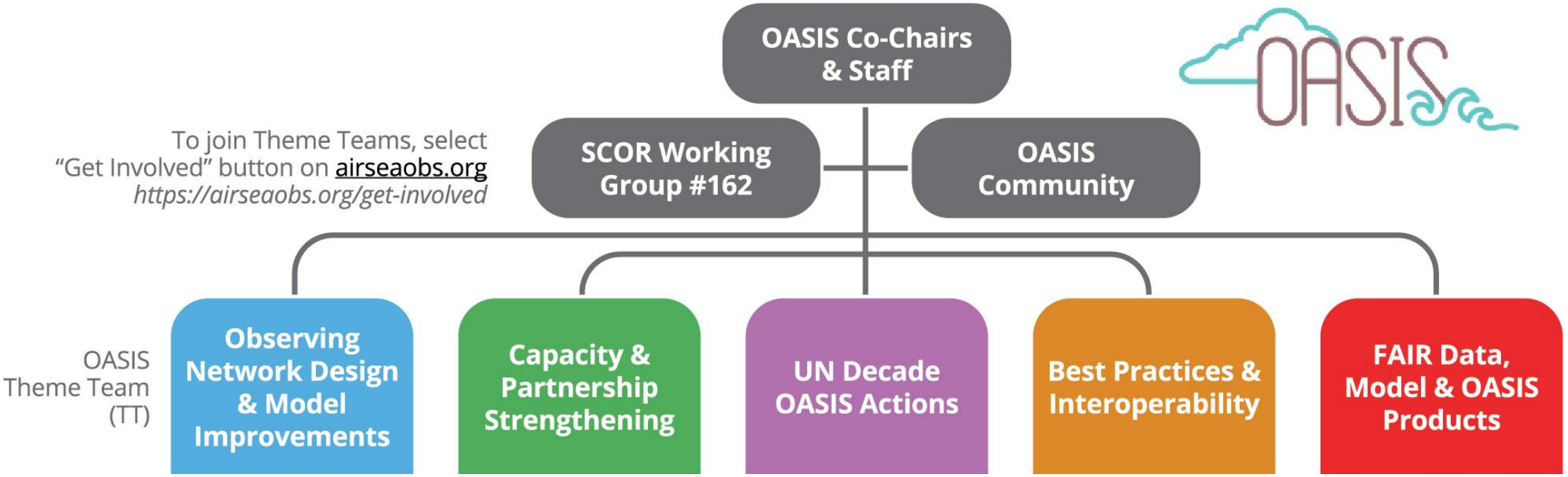
- **Observing Network Design & Model Improvements**
- **Capacity & Partnership Strengthening**
- **UN Decade OASIS Actions**
- **Best Practices & Interoperability**
- **FAIR Data, Model & OASIS Products**



"Best practices are all about efficient sharing of information and learning. Collaboration and community are central. OASIS can be a focal point in this, bringing together air-sea interaction practitioners from around the world."

-- Jack Reeves Eyre

From Ocean Best Practice Systems (OBPS) Air-Sea Interactions workshop, held virtually 11 Oct 2022 at 0700 & 1600 UTC.



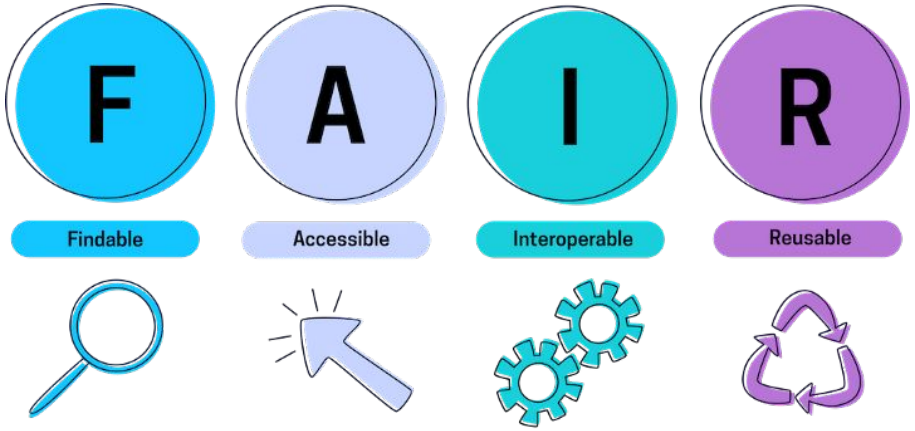
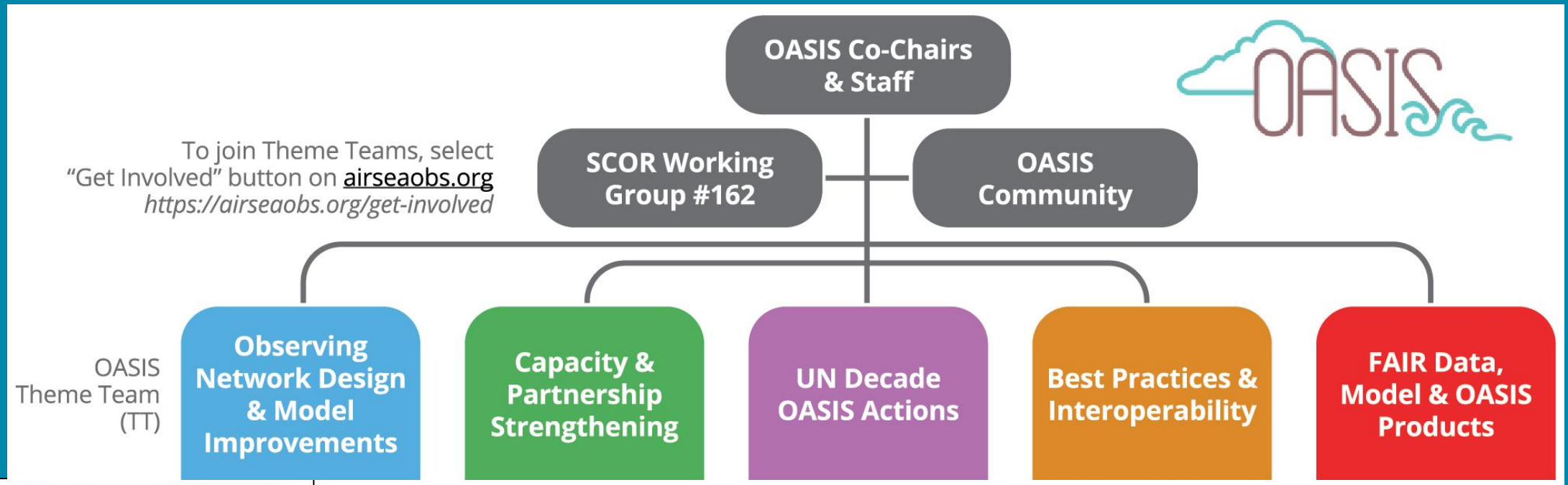


Image: Medium article "Making Data F.A.I.R"

"Our aim is to tackle the grand challenge of standardising air-sea flux terminology, making flux data products and open source code findable and accessible, and elevating the visibility from observation to user data."

-- Marcel du Plessis



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OASIS - SOLAS Scholars from the Surface Ocean-Lower Atmosphere Studies (SOLAS) Open Science Conference in Cape Town South Africa, Sep 25-29, 2022