Further exploiting MW and IR radiances through extracting and using ocean skin temperature information in a coupled ocean-atmosphere system

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Skin Temperature in the ECMWF-IFS

- In the atmospheric 4D-Var, the initial skin temperature (from OCEAN5 and OSTIA) can be optimised using a **sink variable approach**.
- Simulating observations **sensitive to the surface** requires a good knowledge of emissivity and **skin temperature**.
- This is currently used for infrared and microwave observations processed through the clear sky route. **It not yet applied for all-sky microwave observations**.

OSTIA *[Donlon et al., 2012; Met Office, 2023]*
- Merged satellite and in-situ data from UK Met Office.

OCEAN5 *[Zuo et al., 2019]*
- Global reanalysis and real-time analysis from ECMWF.

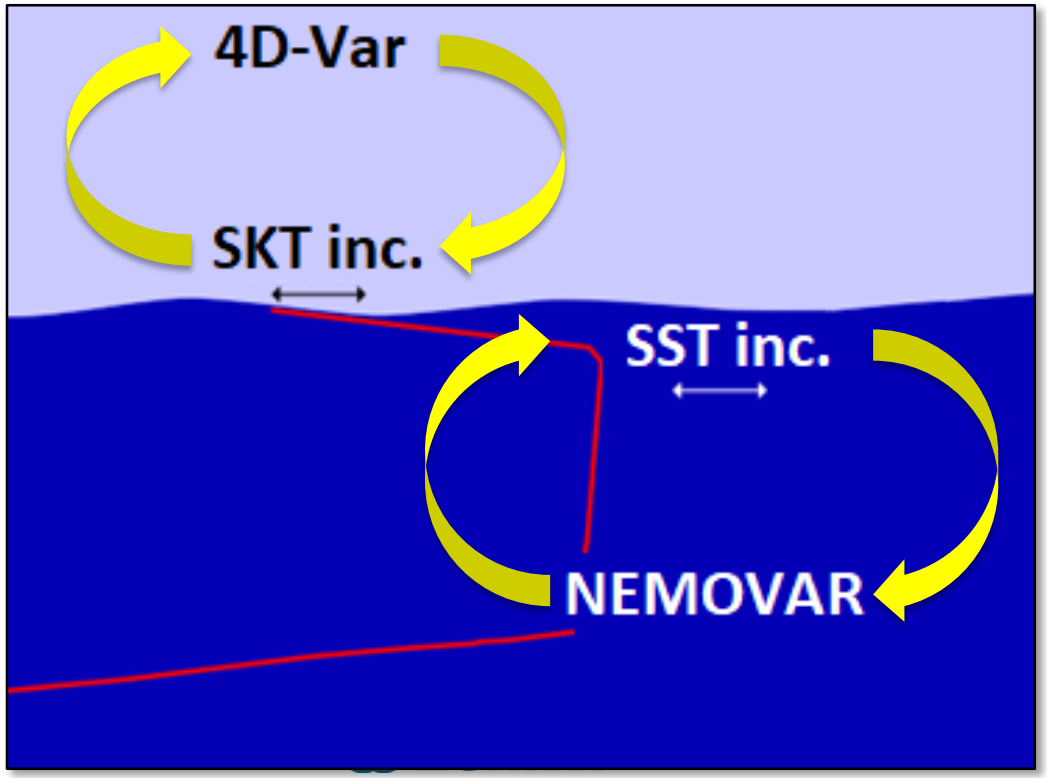
Outline

- Skin temperature derived from IR and used in a coupled system.
- Motivation for application to all-sky microwave observations.
- Relationship between skin and brightness temperatures.
- Skin temperature increments from MW.
- Challenges faced using MW for skin temperature.

Infrared SKT Increments in a Coupled System

[McNally et al., 2022]

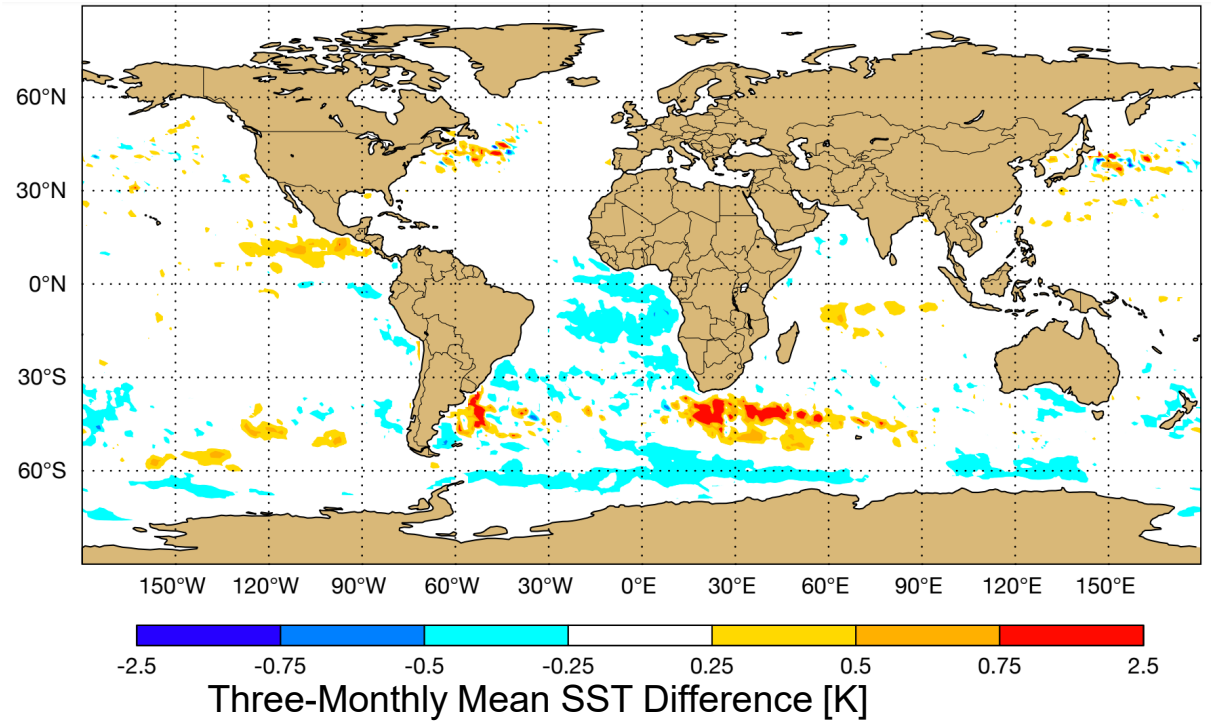
- Constrain the SST so that it is consistent between ocean and atmosphere.
- Skin temperature increments are added directly to the SST.



Sensors

- IASI (Metop-A*, -B, -C)
- CrIS (NPP, NOAA)
- AIRS (AQUA)

*Used in periods where available

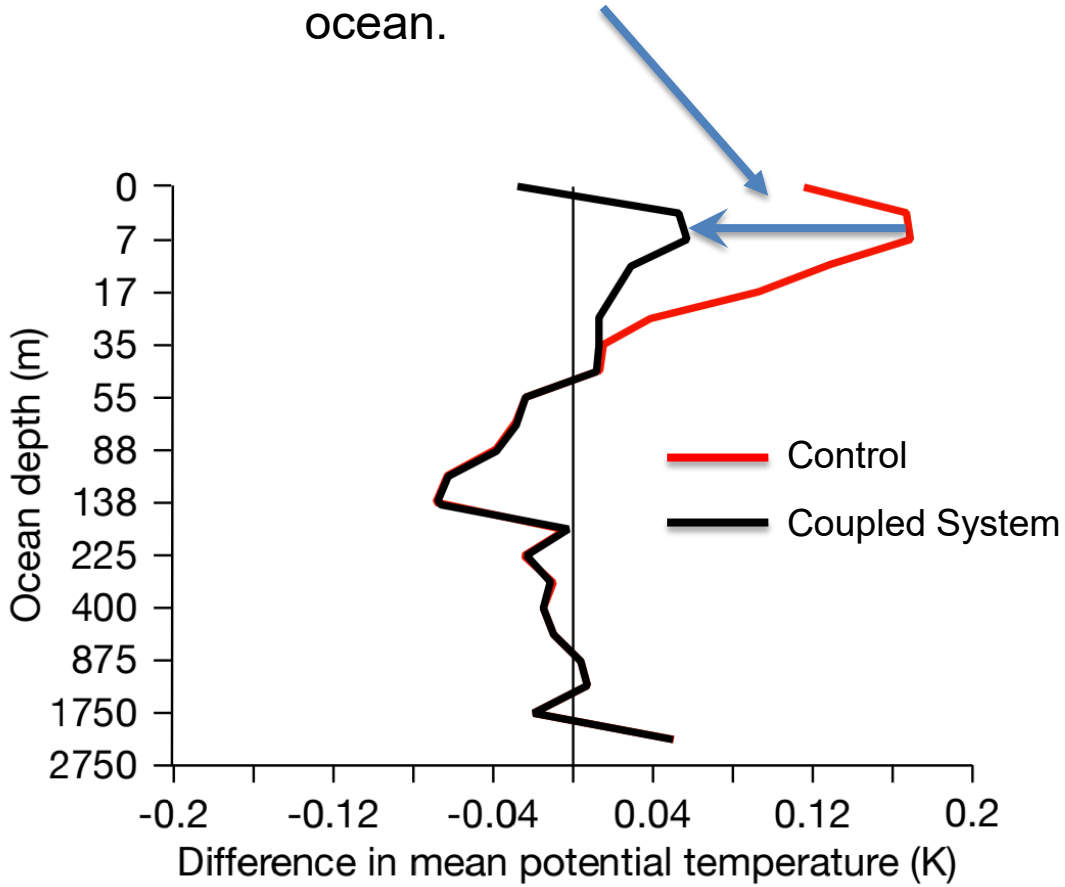


Change in the mean SST for the period 2022-01-01 to 2022-03-07. [McNally et al. (2022)]

Schematic showing how ocean temperature can vary from the subsurface to the skin which is measured by satellites. [Adapted from McNally et al. (2022)]

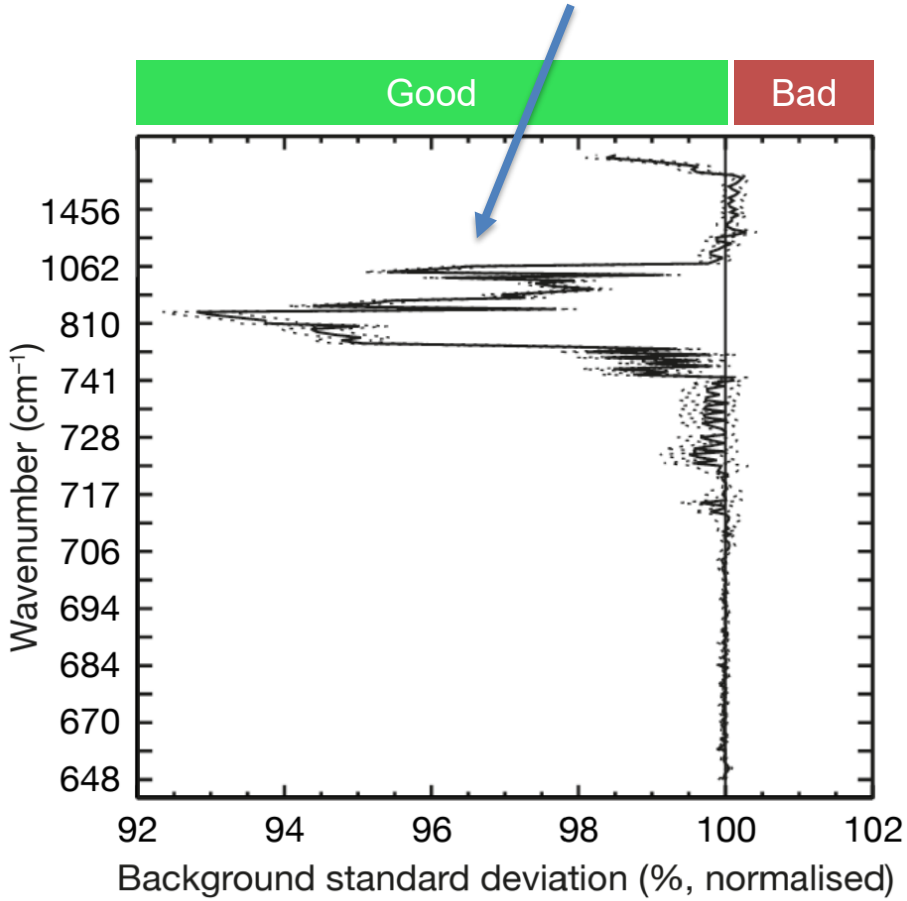
Impact on SST and Atmosphere *[McNally et al., 2022]*

- Improves the fit to independent observations (ARGO floats) of the ocean.



Difference between the RMS of temperature for the forecasts where the skin temperatures are and are not communicated to NEMOVAR. [McNally et al. (2022)]

- Improves the atmospheric system when ocean data fed back in.



Normalised differences in the std. of departures for IASI when ocean information is fed back in to the atmospheric system [McNally et al. (2022)]

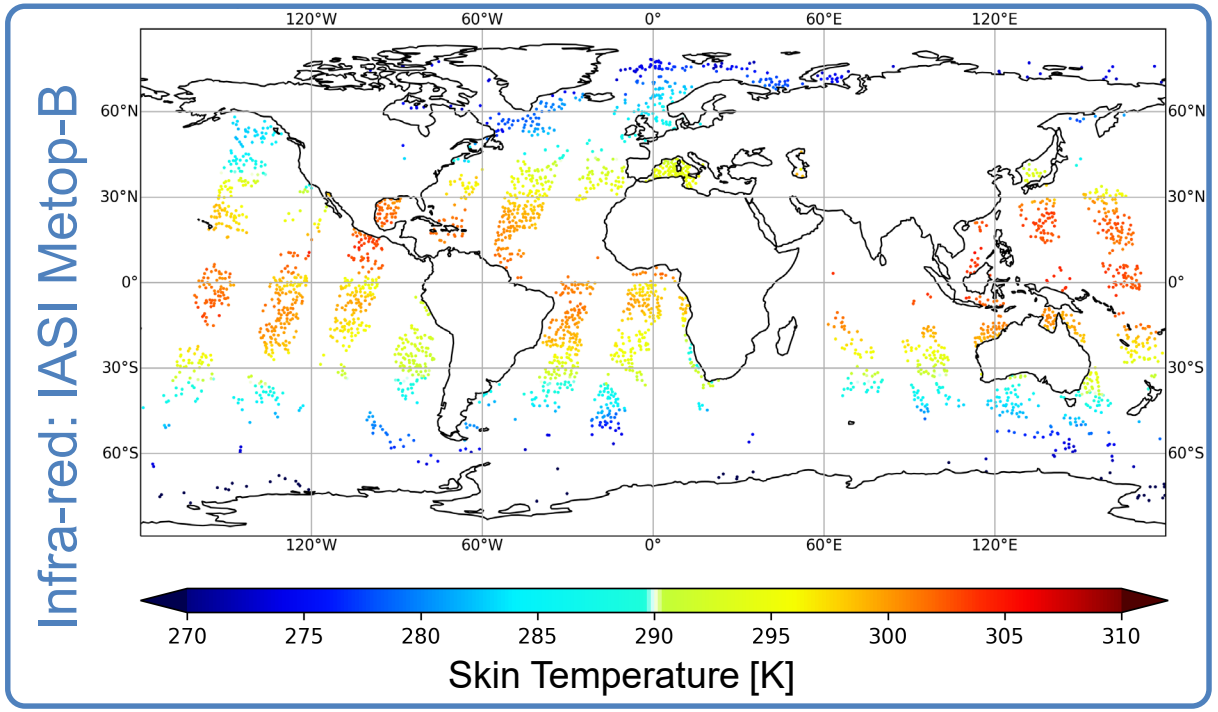
Why apply this method to microwave observations?

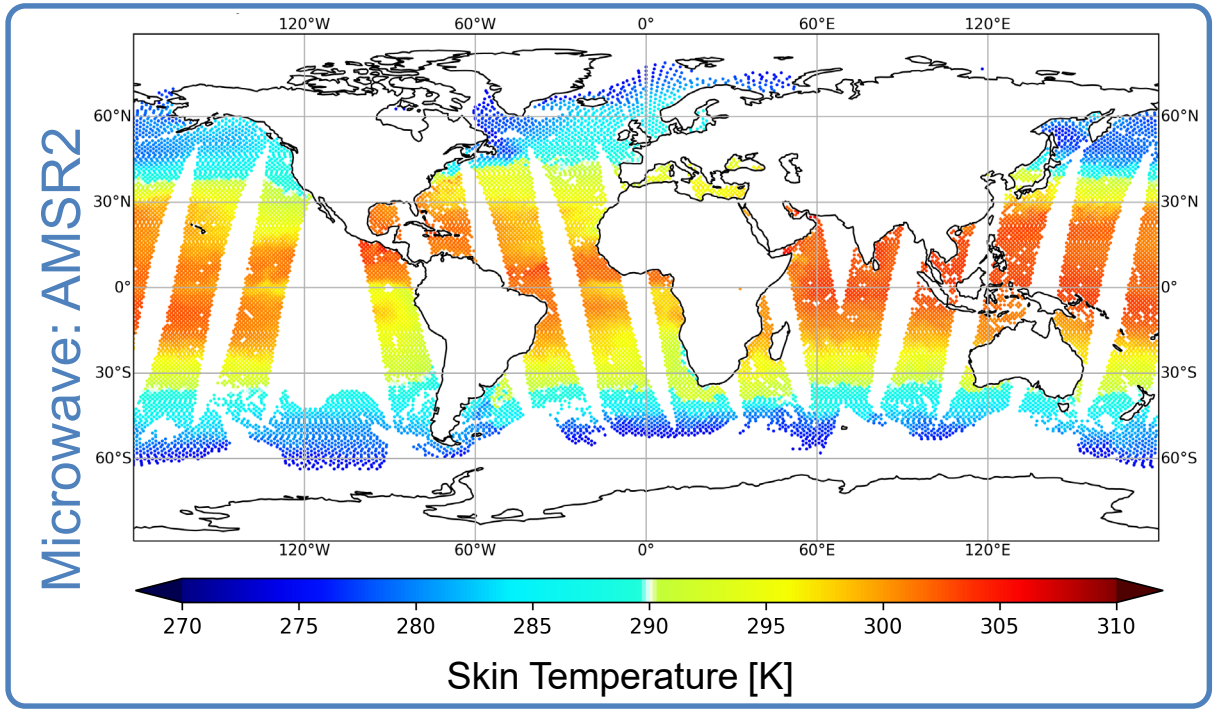
- The key advantage of microwave over infrared is cloudy areas are not screened out, i.e. it is under **all-sky conditions.**
- This minimises use of out-of-date data from external observation-based products.

Experiment

- Include 6v and 10v GHz.
- SKT estimated at actively assimilated locations only.
- SURFEM used.
- All all-sky sensors (AMSR2, MWRI, SSMI/S, GMI, ASMU-A, MHS, MWHS2).
- Only JJA 2020 results shown.

Final skin temperature estimates for assimilated data for (left) IASI 875 cm^{-1} channel and (right) AMSR2 6v GHz channel for 2020-06-15T12.

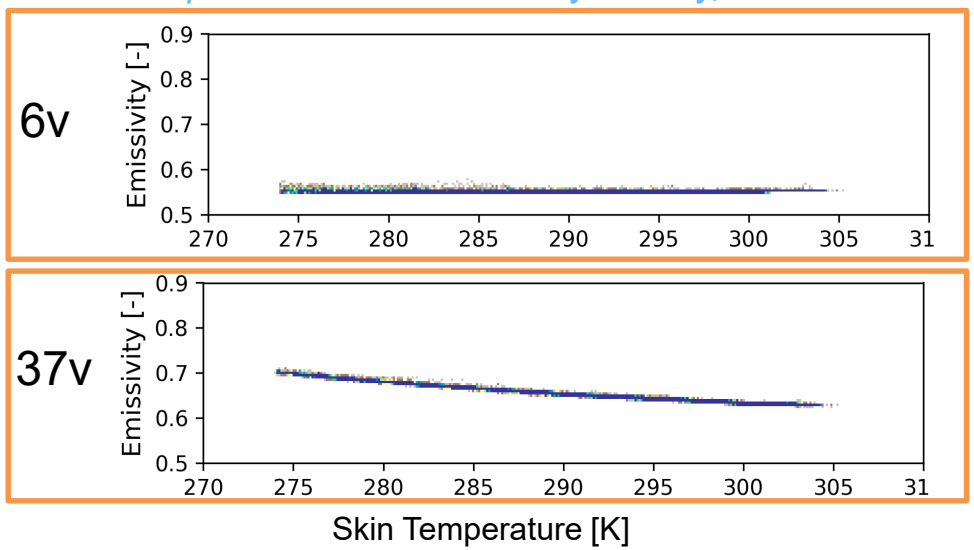


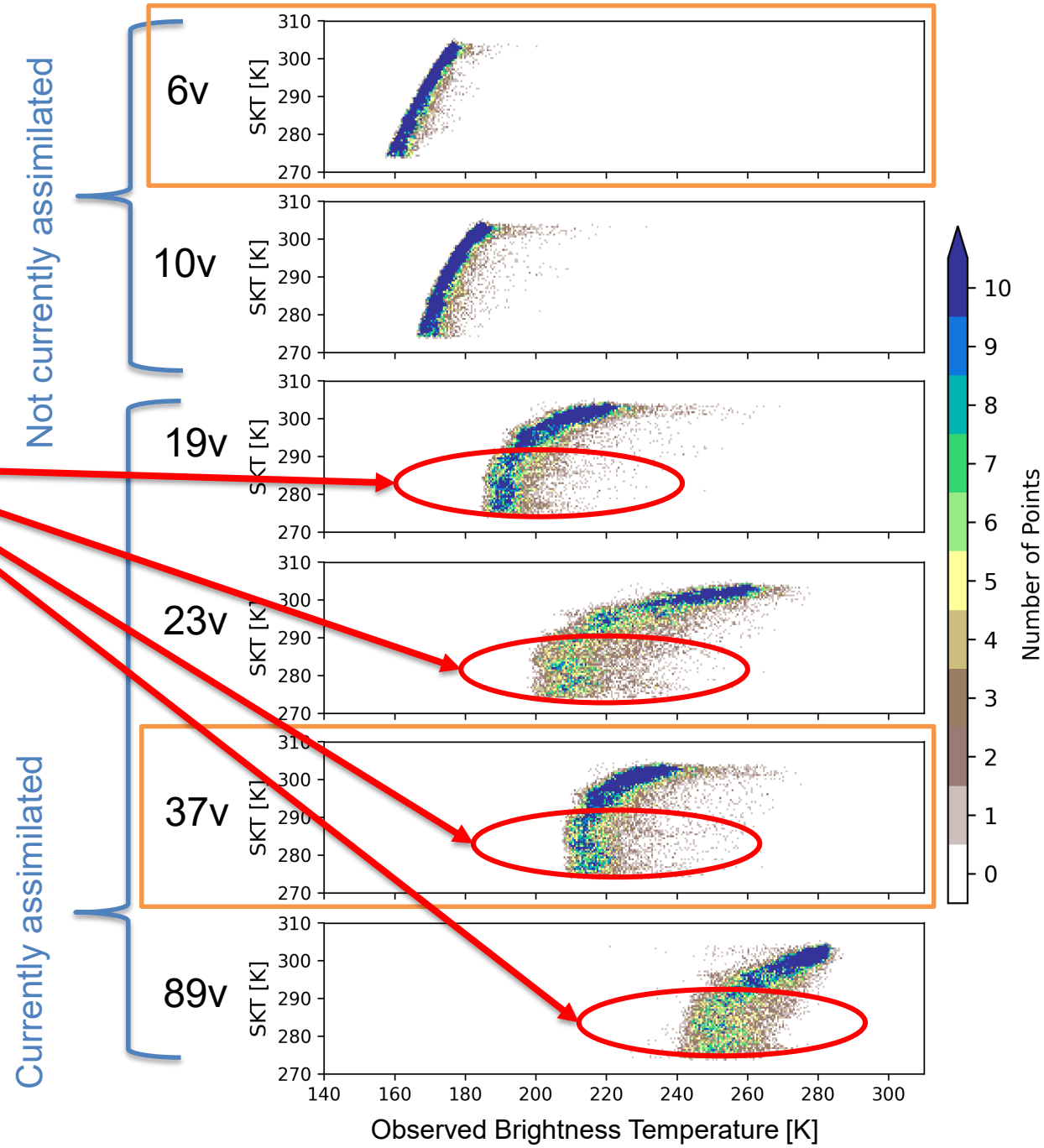


Skin Temperature vs. Brightness Temperature

- As the frequency increases, this linear relationship breaks down due to:
  - Sensitivity to the atmosphere (water vapour, cloud and rain).
  - Surface emissivity temperature dependence.

(Right) TBs vs. SKT for the AMSR2 channels for 2020-06-02T12 and (below) relation between first guess skin temperatures and emissivity. All-sky, over oceans.

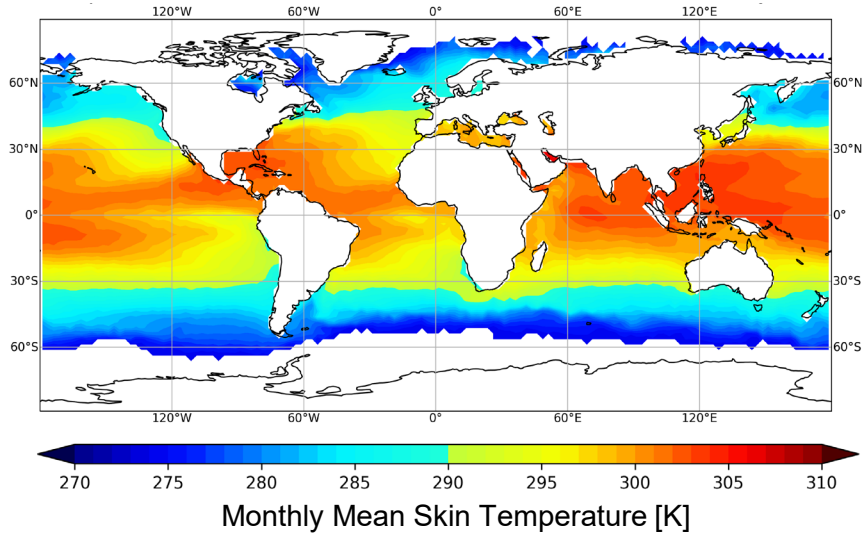


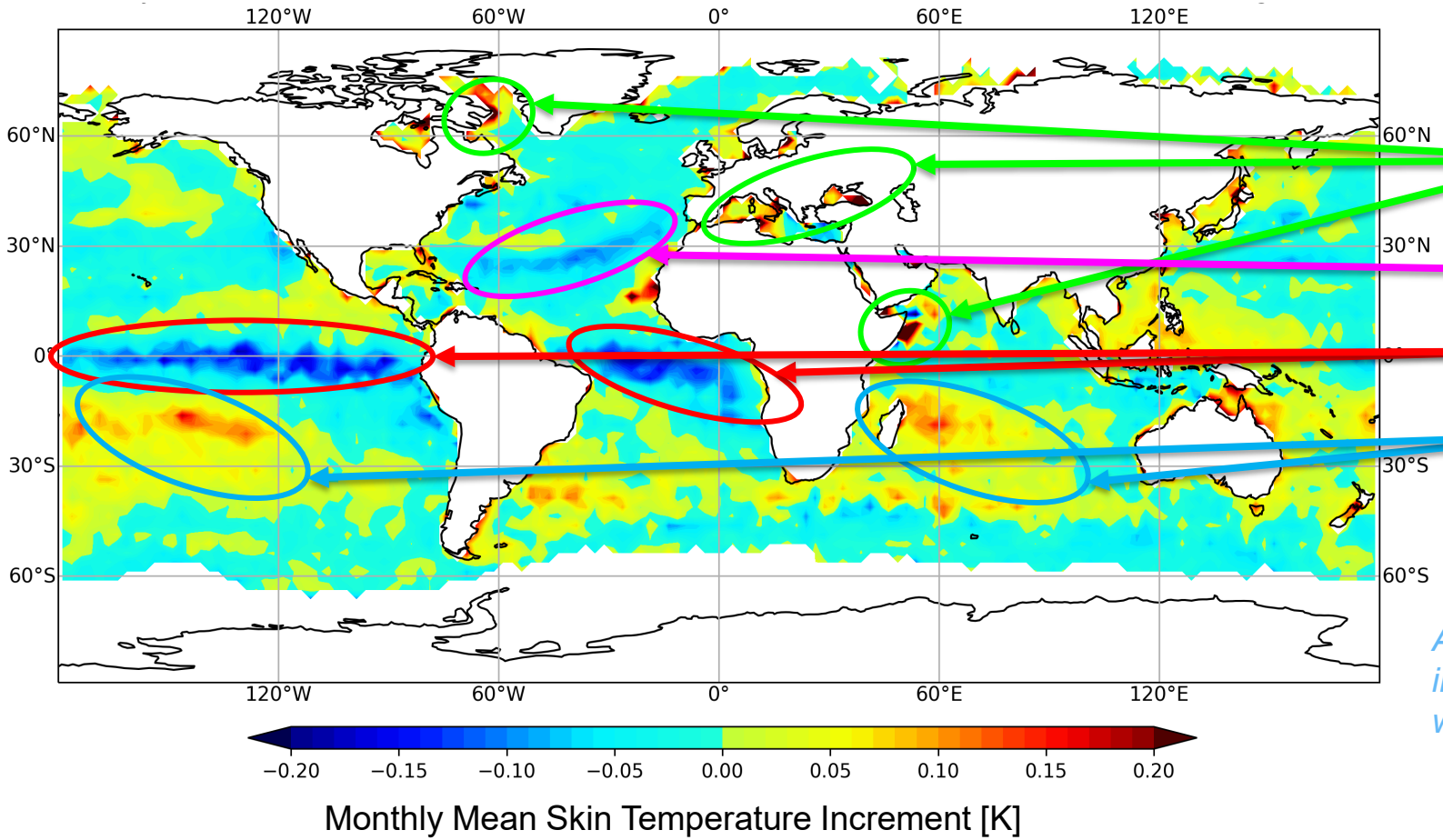


Skin Temperature Increments

- The increments are correlated with features in the skin temperature.
- Large cool increments in the region of cold tongue.
- Southern oceans are warmed.

Final skin temperature for June 2020 for AMSR2 when 6v and 10v GHz are included.





Coastal Regions: RFI and footprint size?

Bias to ship measurements?

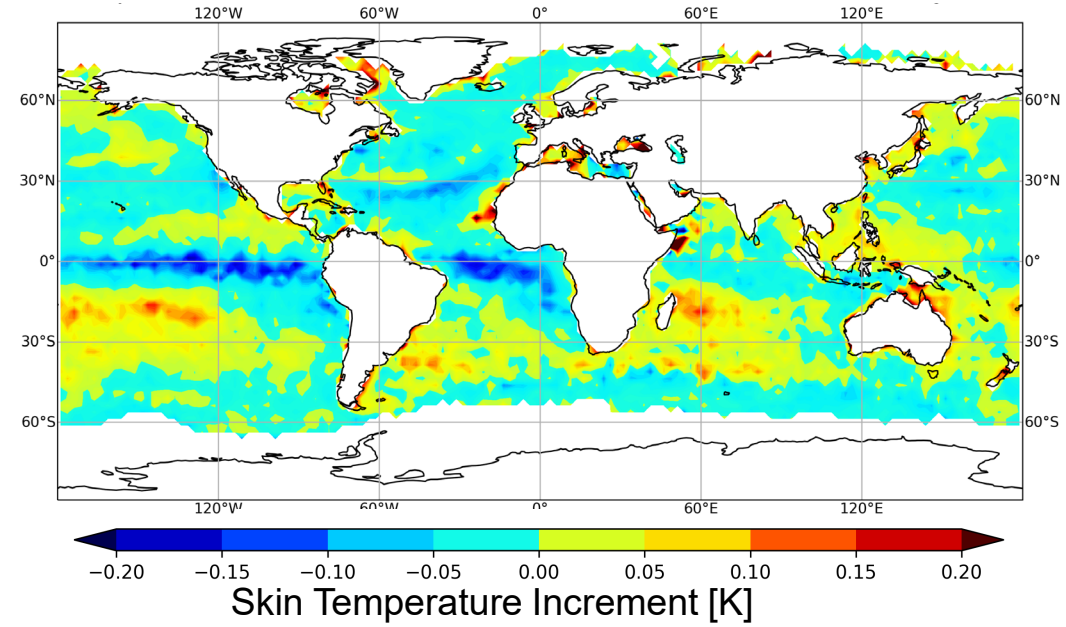
Cold tongue – tropical instability

Warming southern oceans

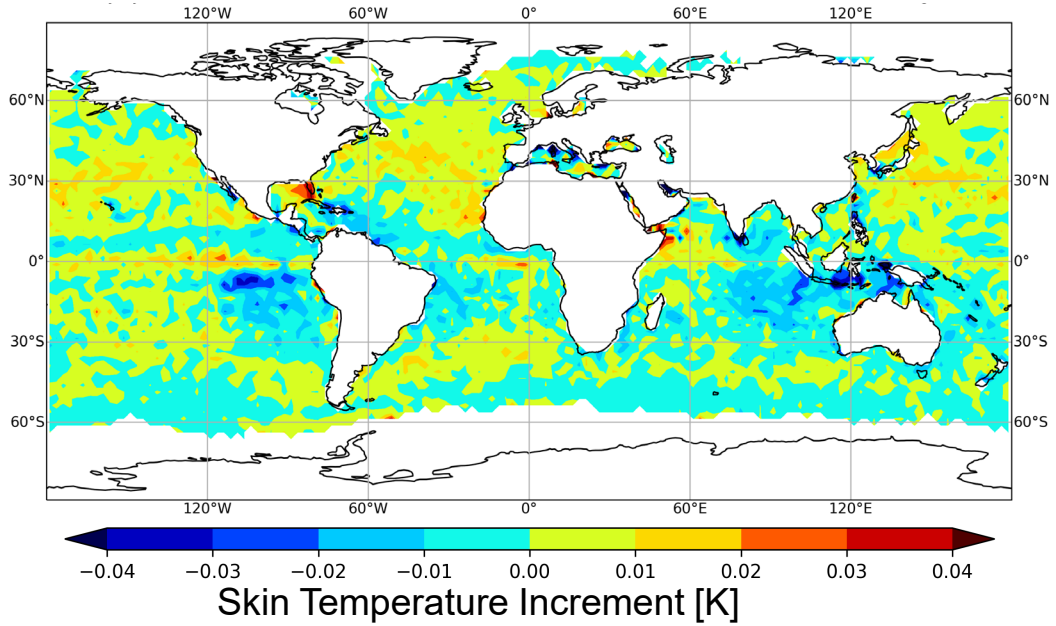
Average skin temperature increments for July 2020 for AMSR2 when 6v and 10v GHz are included.

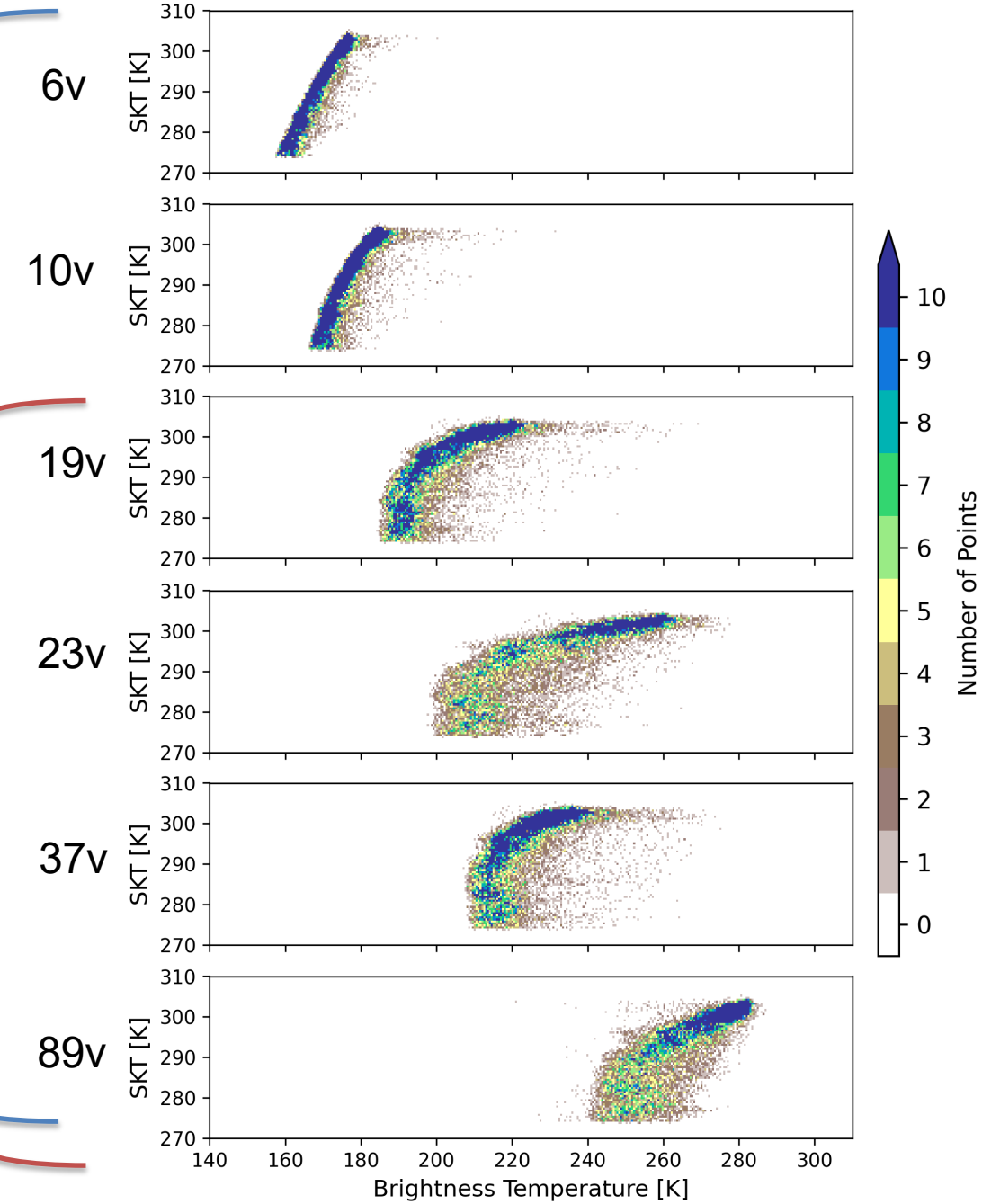
Impact of 6v and 10v GHz

With 6v and 10v GHz



Without 6v and 10v GHz

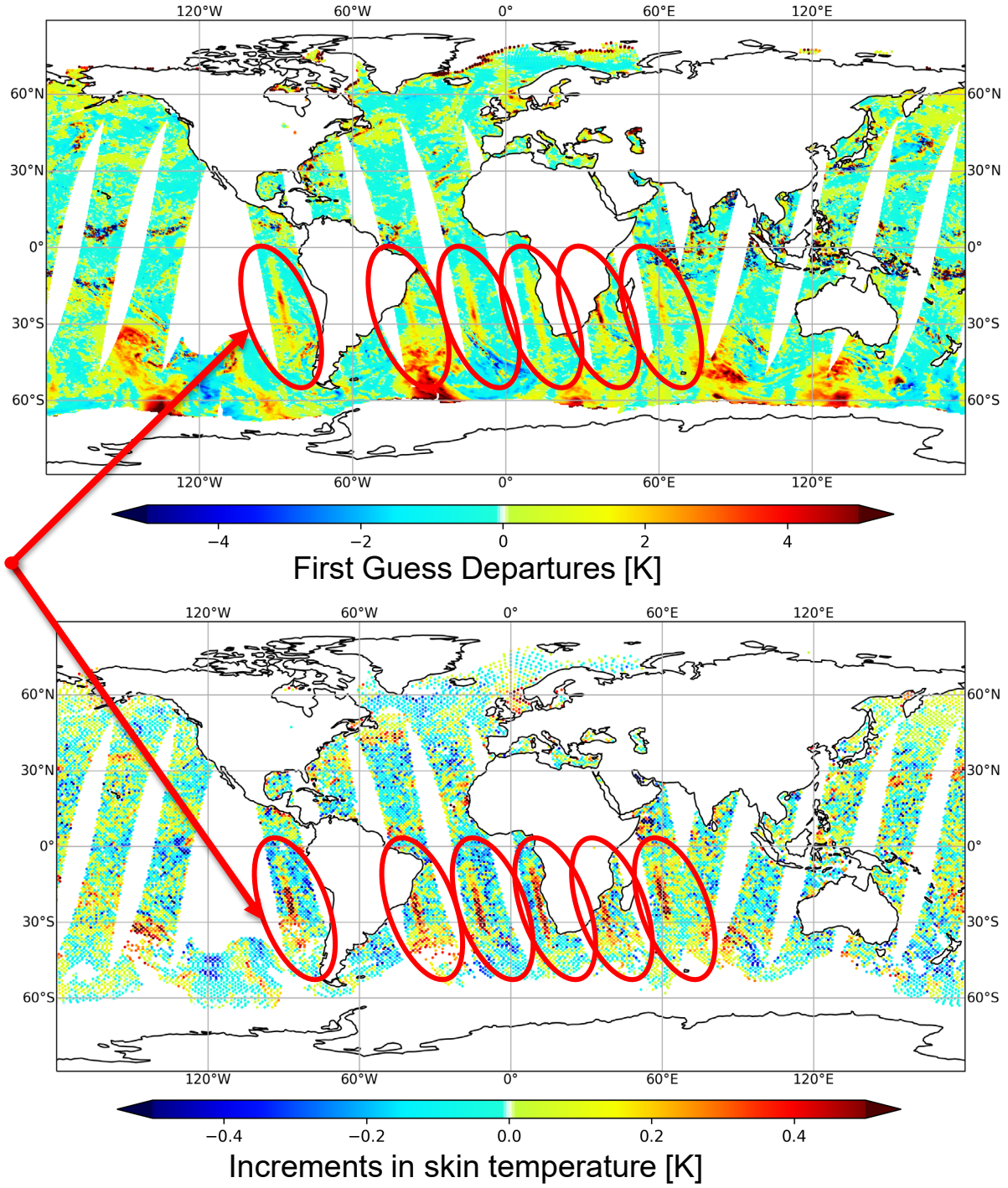




Sun glint in 6v GHz

- Sun glint is apparent in the first guess departures for 6v GHz (AMSR2).
- Also seen in 10v GHz but not higher frequencies.
- This is aliased into the skin temperature increments.
- Will need to develop screening or bias correction to address this.

Sun glint is aliased into skin temperature increments



First guess departures for AMSR2 6v (top) and skin temperature increments (bottom) for 2020-06-15T12.

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Further Work

- **Infrared**: skin temperature incremented in 4D-Var and used in a coupled system to provide benefit to the ocean and atmosphere.
- **Microwave**: skin temperature incremented in 4D-Var and testing ongoing understand the output. Areas to investigate include:
  - Sun glint and RFI in 6v and 10v GHz.
  - Potential issues around coastal areas.
  - Aliasing of cloud or systematic errors into skin temperature.
  - Diurnal and rapid variations in the skin temperature.
  - Use of different combinations of microwave sensors.
- Final aim is to use microwave in a coupled system to improve the ocean and feedback into the atmospheric analysis.

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Questions?

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