

A Cross-Domain Air Temperature Analysis for the MOTECUSOMA Project

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1. Introduction

Within the ESA MOTECUSOMA project, a global surface air temperature data set is being developed by combining air temperature estimates from satellite surface temperature retrievals with in situ measurements.

This approach aims to product globally complete estimates of air temperature change, improving spatial coverage of air temperature estimates, particularly over regions with limited in situ observations. The work focuses on integrating multiple data sources within a common analysis framework, with particular emphasis on representing and quantifying uncertainty.

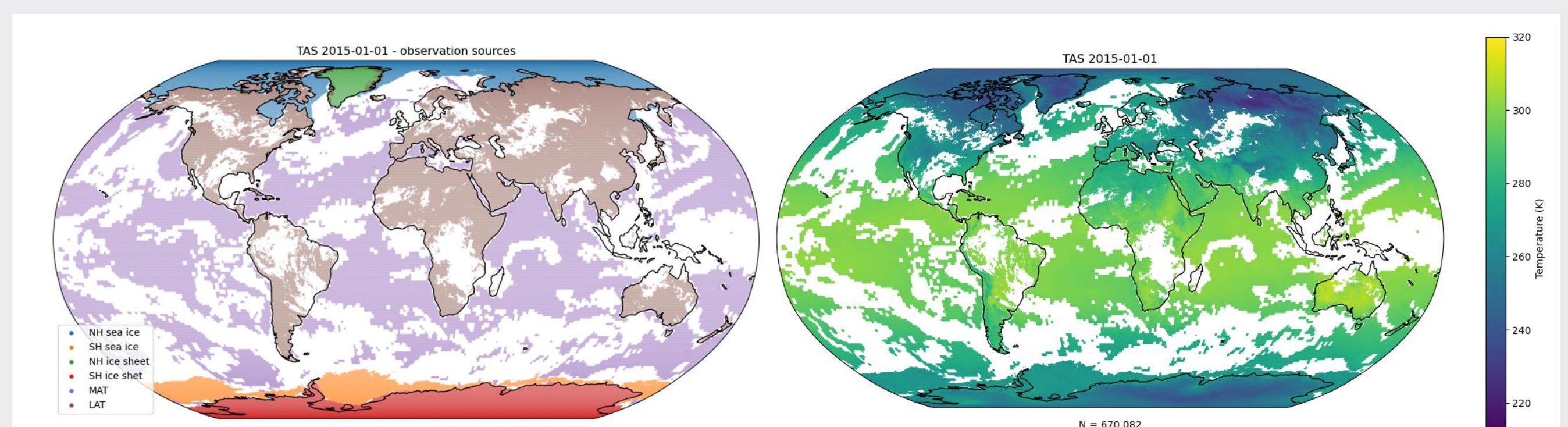
This work supports the broader MOTECUSOMA project objectives of improving understanding of energy flows in the climate system by improving the observational basis for assessing recent climate change and variability.

This poster describes ongoing work to develop the air temperature analysis data set, presenting early results from a trial run of the analysis system.

2. Observation Data

Within the MOTECUSOMA project, 2m air temperatures are inferred over land, water and ice from relationships with satellite retrieved surface temperatures, including from ESA CCI products (see other MOTECUSOMA posters).

These air temperature estimates, and their uncertainties, are combined using a statistical model to create a globally complete gridded data set. Initial results shown here use on satellite retrieved air temperatures. Trials are currently underway to additionally use in situ air temperatures over land and water.



Observations input into the trial analysis for a single day, showing (left) satellite data sources and (right) retrieved air temperatures. White areas represent missing data regions.

3. Analysis Methods

Air temperature observations y are modelled as a combination of **temperature fields** and **observation error** terms in a Linear Gaussian Model:

$$y = T(s, t) + \beta(s, t) + \epsilon$$

$$= Au + c + Bv + \epsilon$$

Temperature Model:

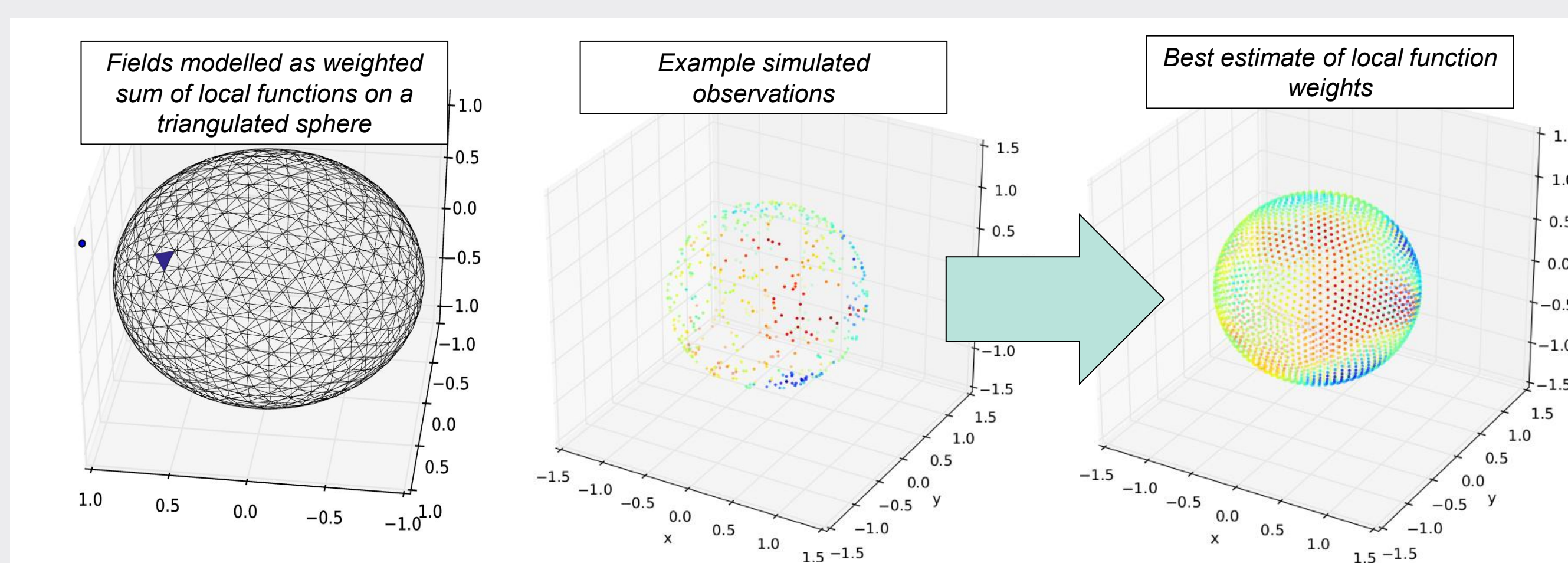
- Local basis function model and covariates Au plus additive climatology c
- Interpolates using a spatially correlated Gaussian prior $p(u|\theta)$ on local function weights

Observation Error model:

- Systematic and locally correlated errors Bv and uncorrelated errors ϵ
- Observation uncertainty models define the structure of B and distributions $p(v)$ and $p(\epsilon)$

Estimation:

- We evaluate the joint distribution $p(u, v|y, \theta)$ of temperature coefficients u and error model coefficients v conditioned on the observations.
- Uncertainty ranges and ensemble samples are computed from this distribution



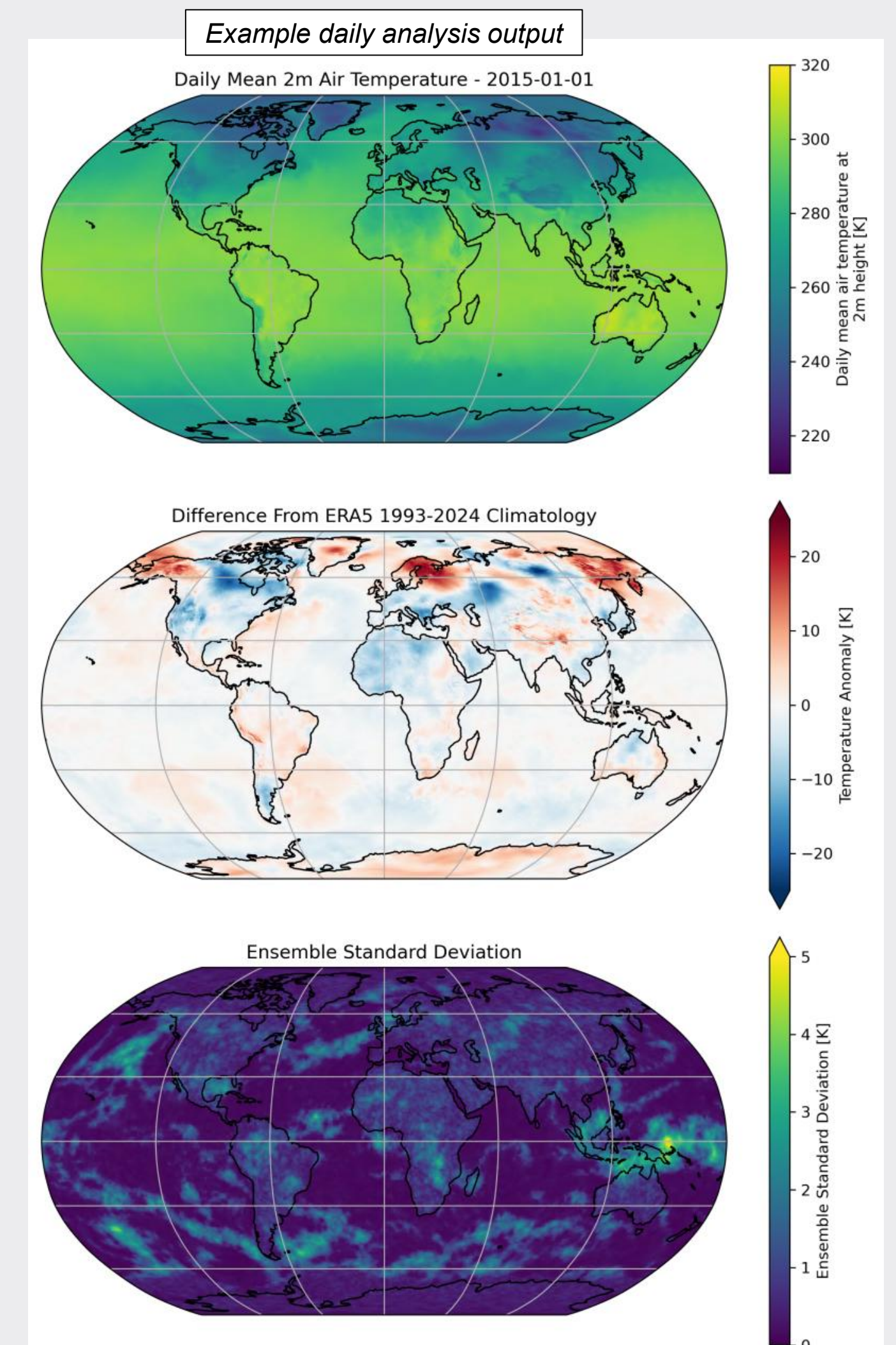
4. Trial Analysis Results

Here we present examples of the analysis output from an early trial run.

This trial run used early versions of the satellite input data. The trial covers two years, 2015 and 2016, using a climatology based on ERA5. This climatology will be updated in the final product.

Observation error modelling was based on uncertainties provided in the input data sets. Structured, locally correlated and uncorrelated error terms were mapped onto appropriate statistical analysis error model components. Representation of these terms was found to be critical to estimate coherent temperature fields from the variety of data sources assimilated.

Initial results indicate capability to represent variation in regional and global average temperatures.



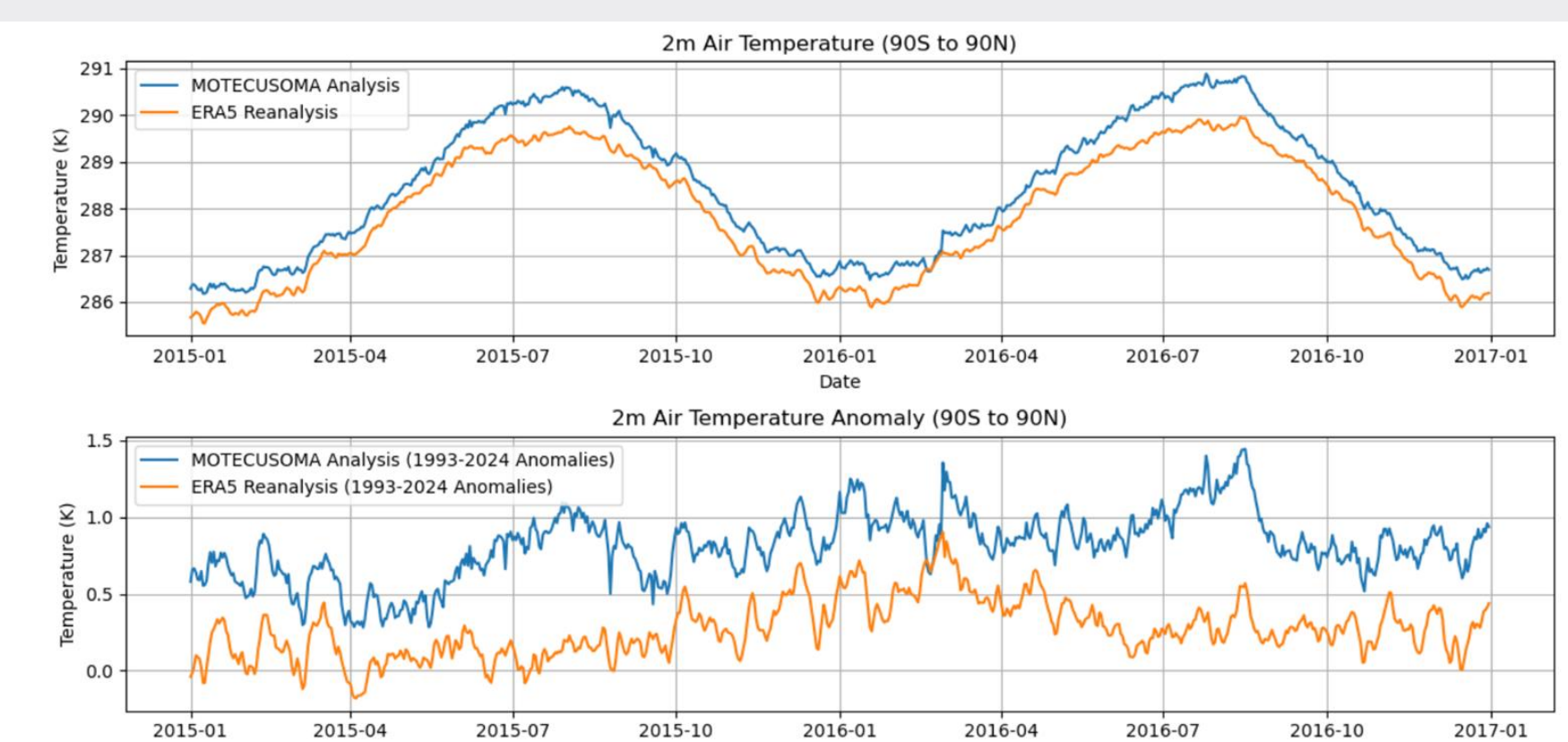
5. Ongoing Work

This poster presents ongoing work to produce a global air temperature analysis using satellite-based estimates of daily air temperatures.

Work is ongoing to refine the statistical analysis model, including improvements in the representation of regional variability, production of a refined climatology and improvement to representation of structured observation errors (locally correlated and systematic). In parallel, the input observation data sets contributing the analysis are being finalised by the MOTECUSOMA team.

The final version of the analysis will be run in 2026 and will contain data over 1996-2025.

Daily global average air temperatures from the trial analysis over 2015-2026 showing (top) temperature comparison to ERA5 and (bottom) differences from climatology for an ERA5 based climatology.



Work described in this poster has been undertaken as part of the ESA MOTECUSOMA project.

