IMPERIAL

Adapted from:
Driver, O.G.A., Stettler, M.E.J., Gryspeerdt, E., 2025. The ice supersaturation biases limiting contrail modelling are structured around extratropical depressions. [preprint] EGUsphere 1–24. https://doi.org/10.5194/egusphere-2025-2737

Understanding meteorological limitations using the structure from weather systems

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Edward Gryspeerdt, Marc Stettler

Ice supersaturation enables ice crystals (and contrails) to persist

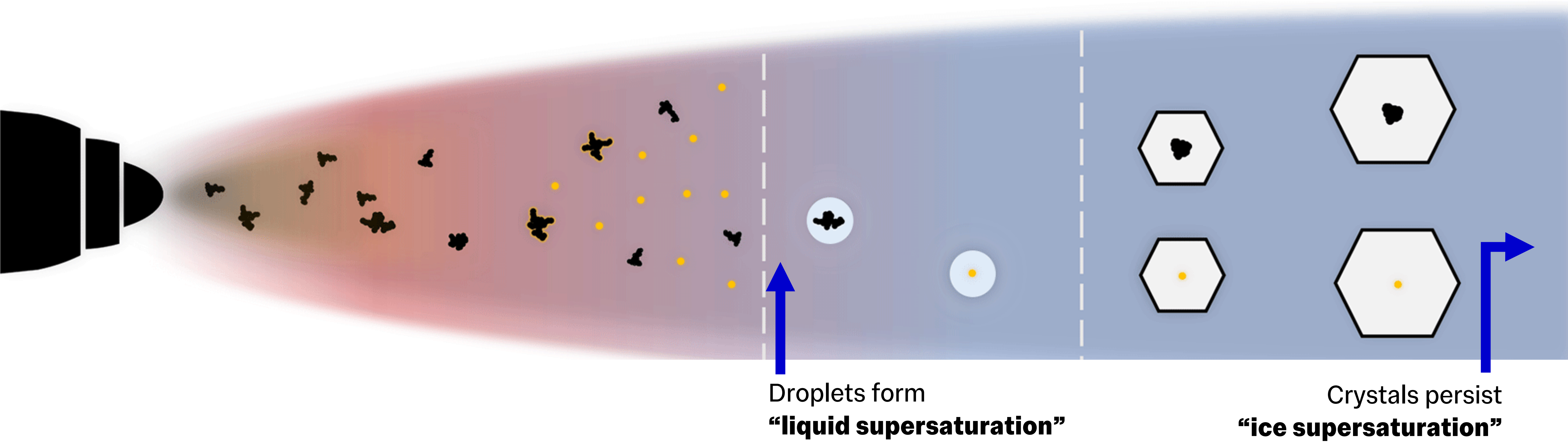
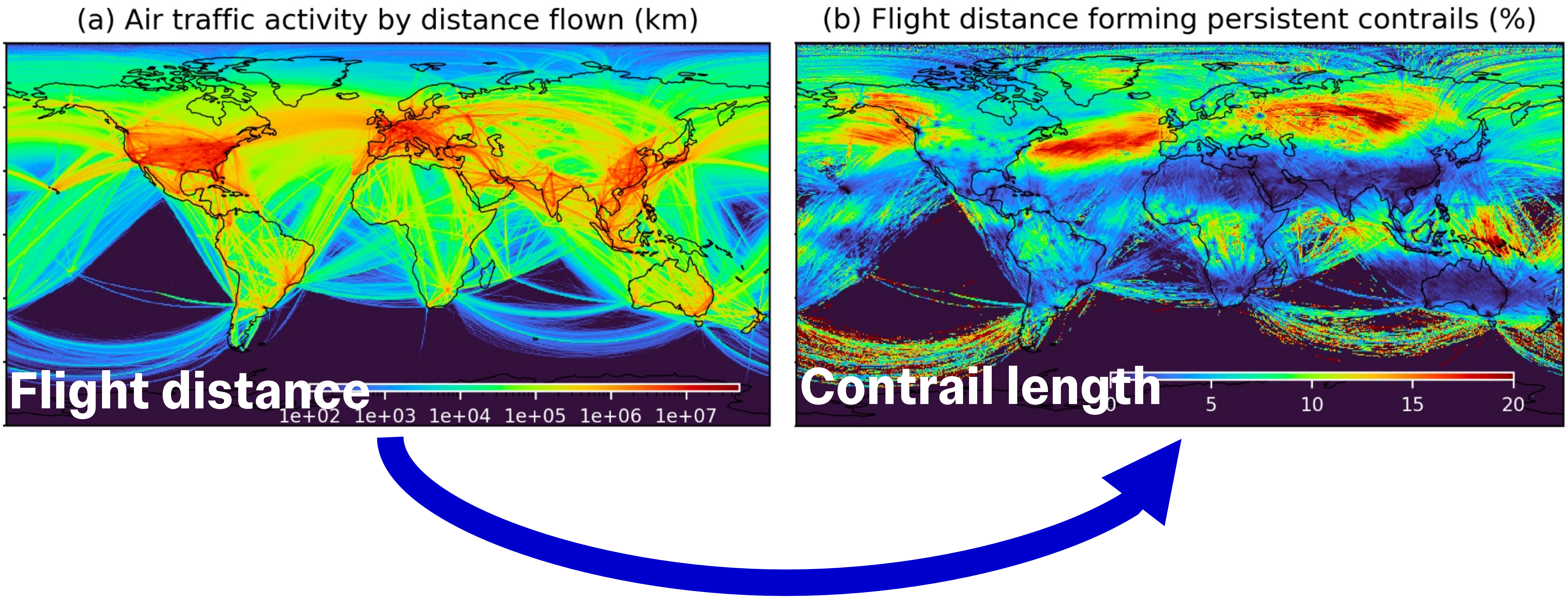


Figure adapted from: Ponsonby et al. 2024, *Atmos. Chem. Phys.*

Contrail models combine this with air traffic and meteorology



Meteorology, aircraft details, contrail formation and persistence

Figure adapted from: Teoh et al. 2024, *Atmos. Chem. Phys.*

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Teoh, R., Engberg, Z., Schumann, U., Voigt, C., Shapiro, M., Rohs, S., Stettler, M.E.J., 2024. Global aviation contrail climate effects from 2019 to 2021. Atmospheric Chemistry and Physics 24, 6071–6093. https://doi.org/10.5194/acp-24-6071-2024, under Under CC-BY 4.0.

What stands between us and confidence in contrail models?

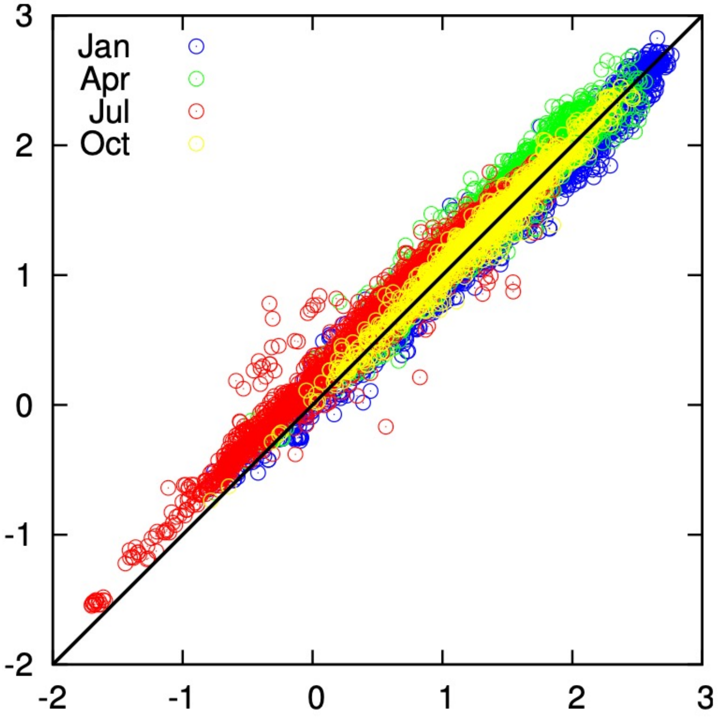
How do we validate them?

Observed contrails	Modelled contrails
In geostationary imagery, narrow or optically thin contrails go undetected.	Ice supersaturation modelling carries limiting biases.

The formation can be modelled, but the persistence can't

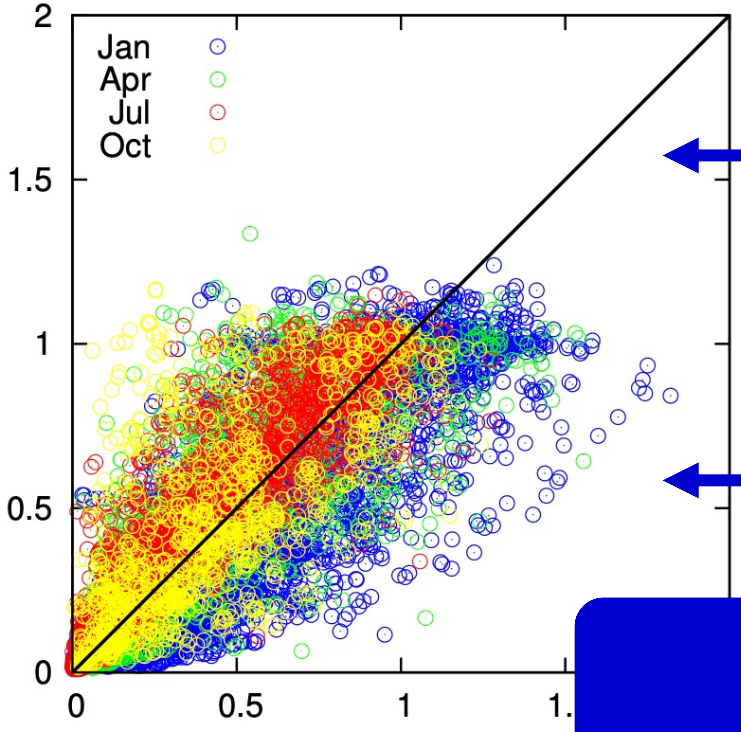
Formation

Mixing relative humidity to liquid water



Persistence

Relative humidity to ice



High RHi values missing

Poor case-by-case agreement

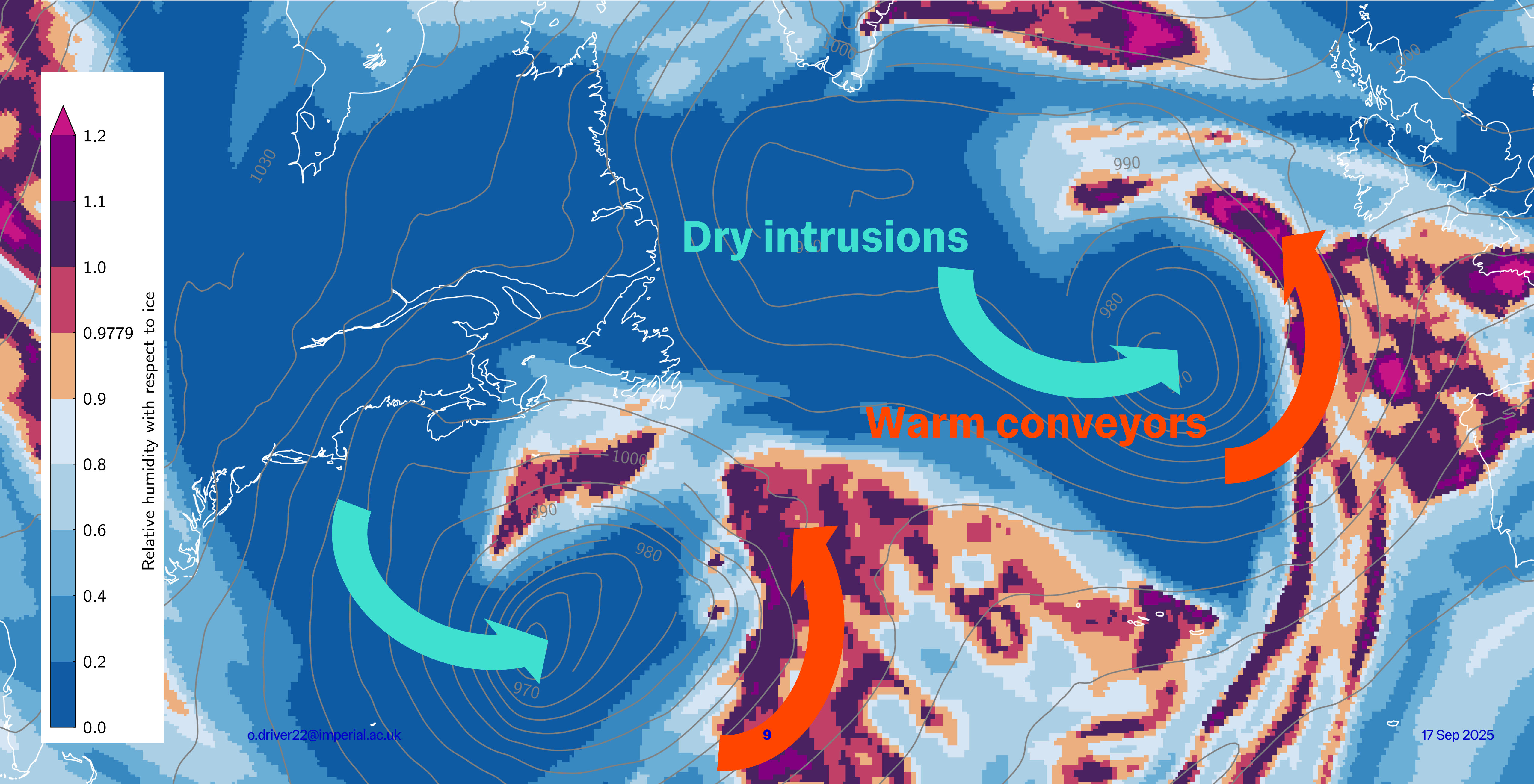
RHi is a mess?

Models →

Observations →

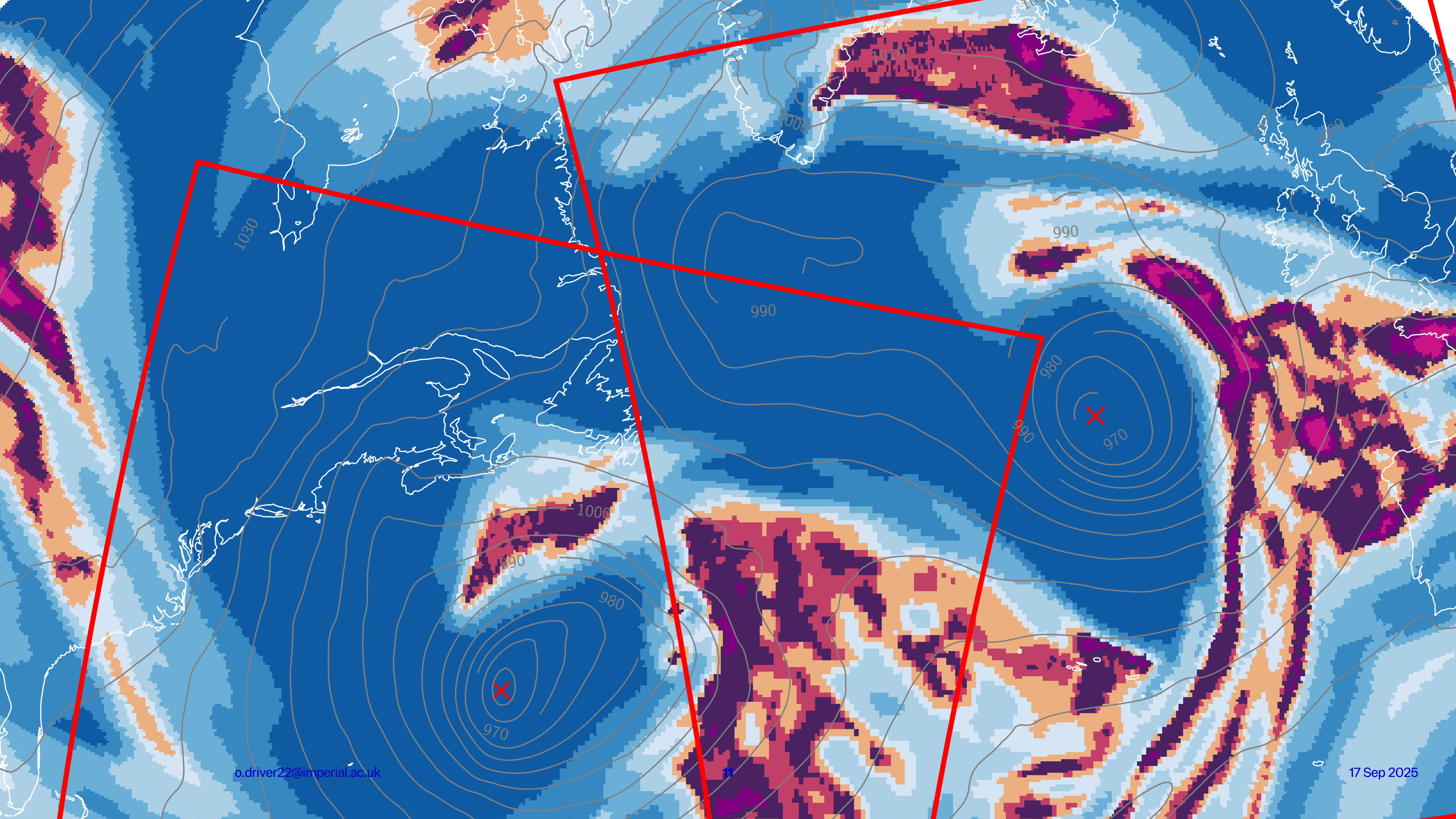
Figures reproduced from: Gierens, Matthes, and Rohs 2020, Aerospace (doi.org/10.3390/aerospace7120169)

Low pressure systems structure the weather



How are ISSRs structured around weather systems?

How do biases emerge from the underlying processes?


1030
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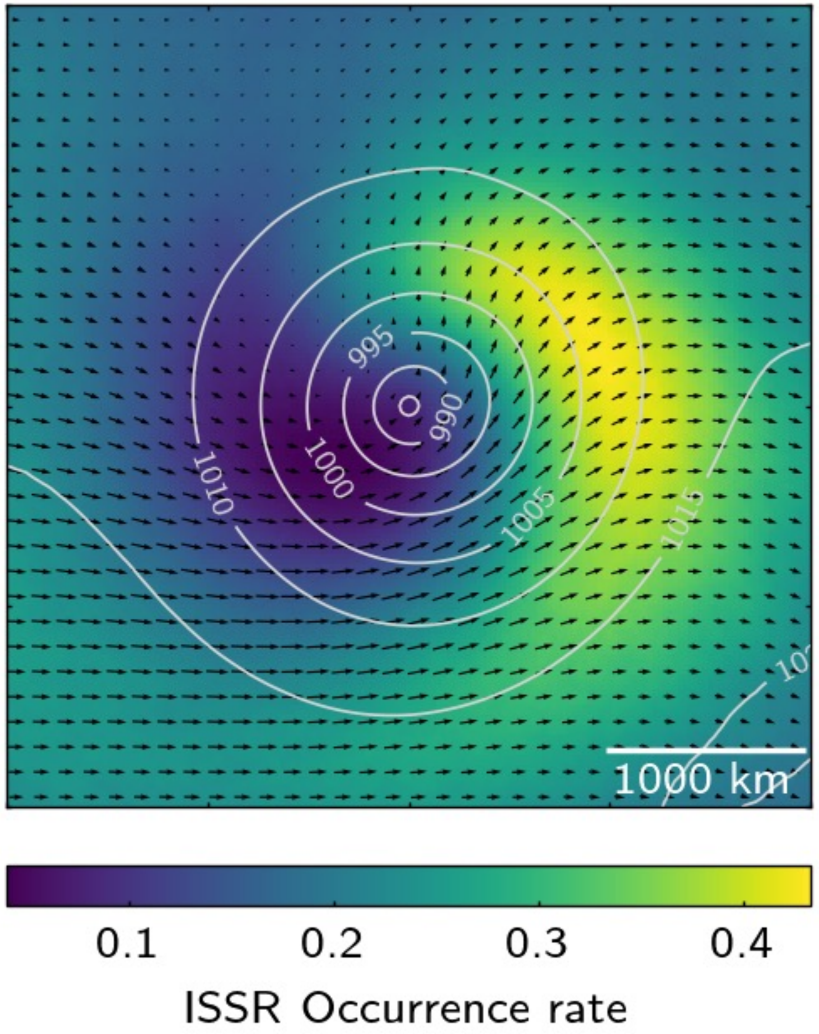
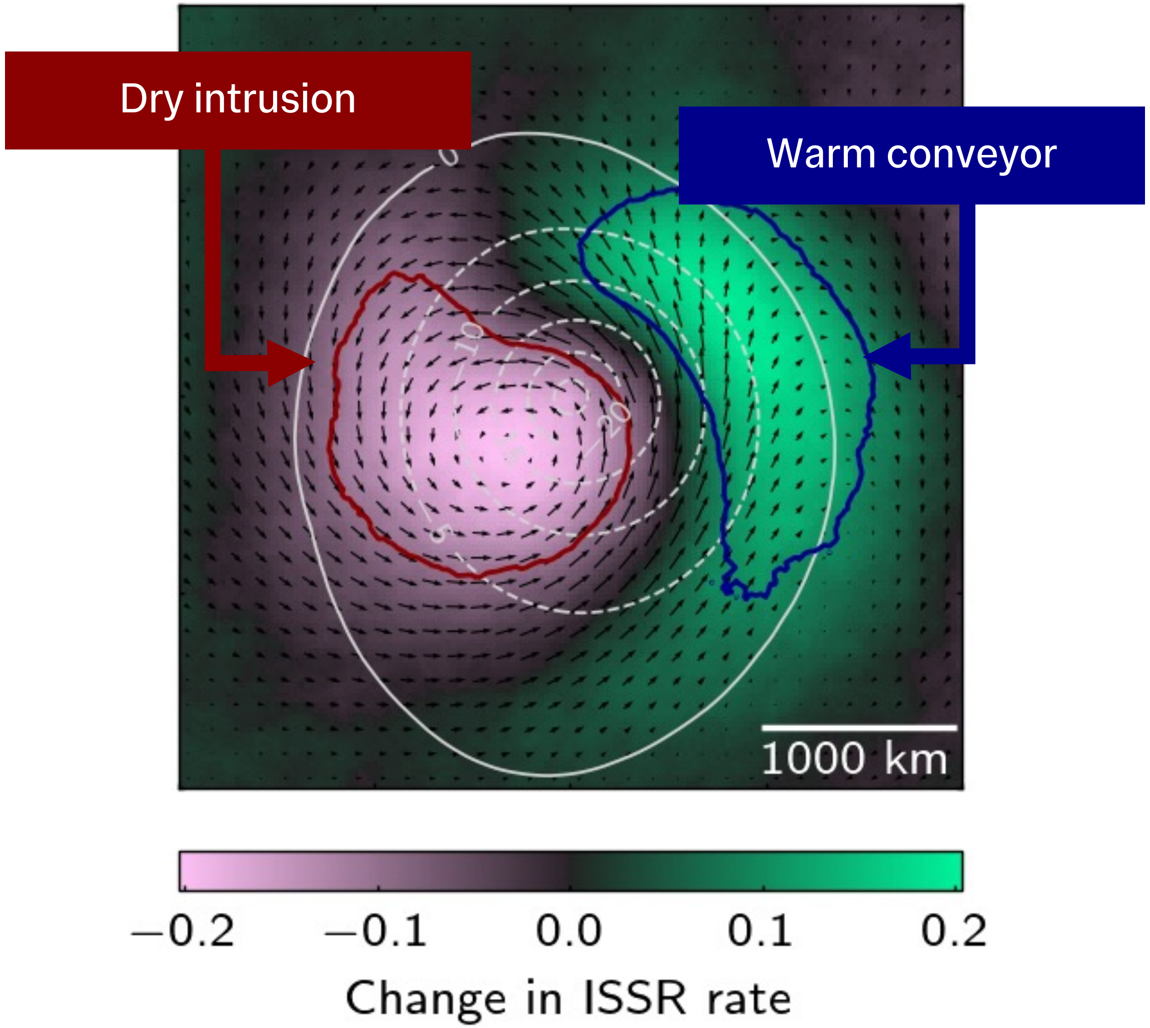
The rate of ERA5 ISSRs is structured around low pressure systems





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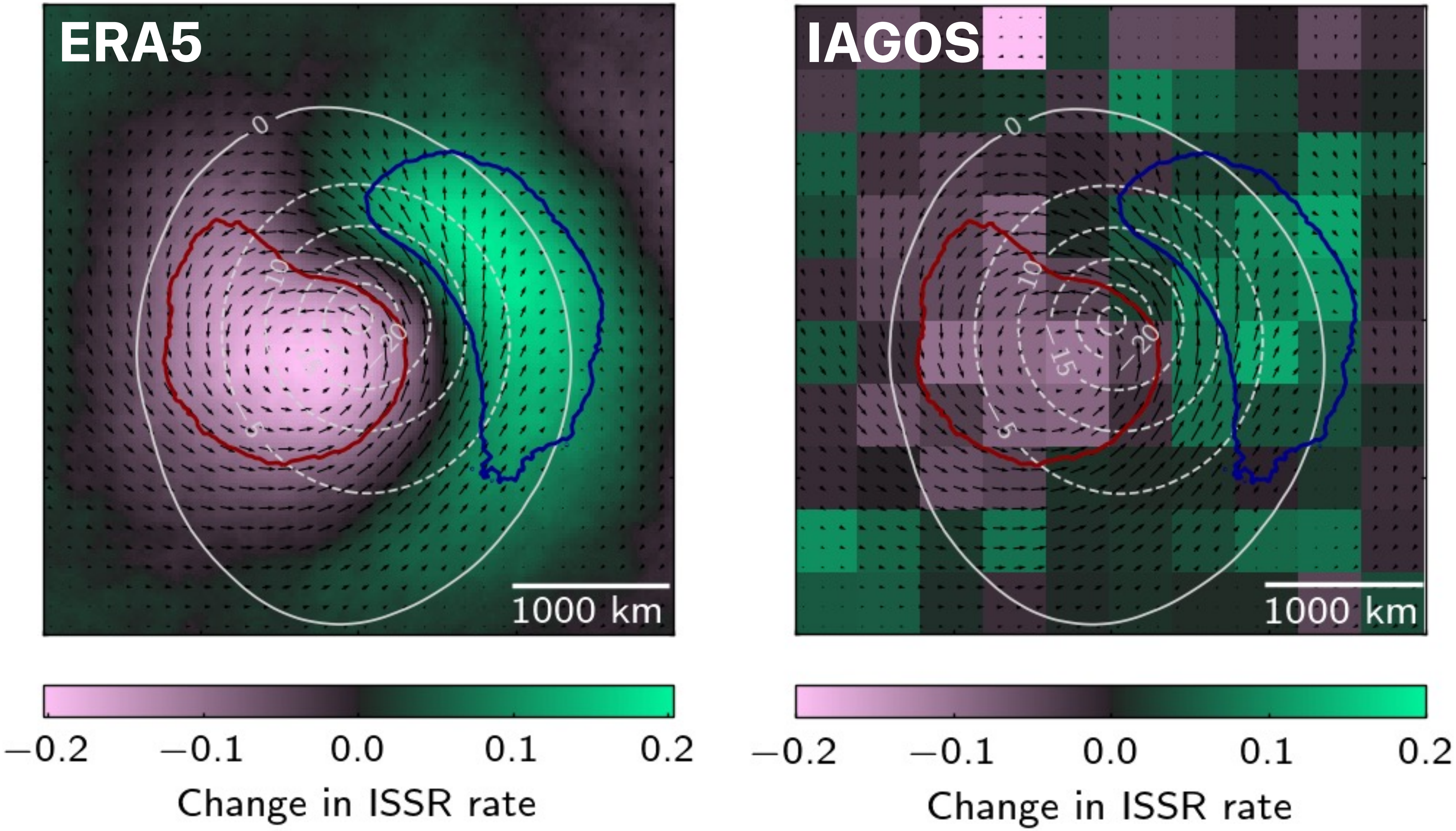
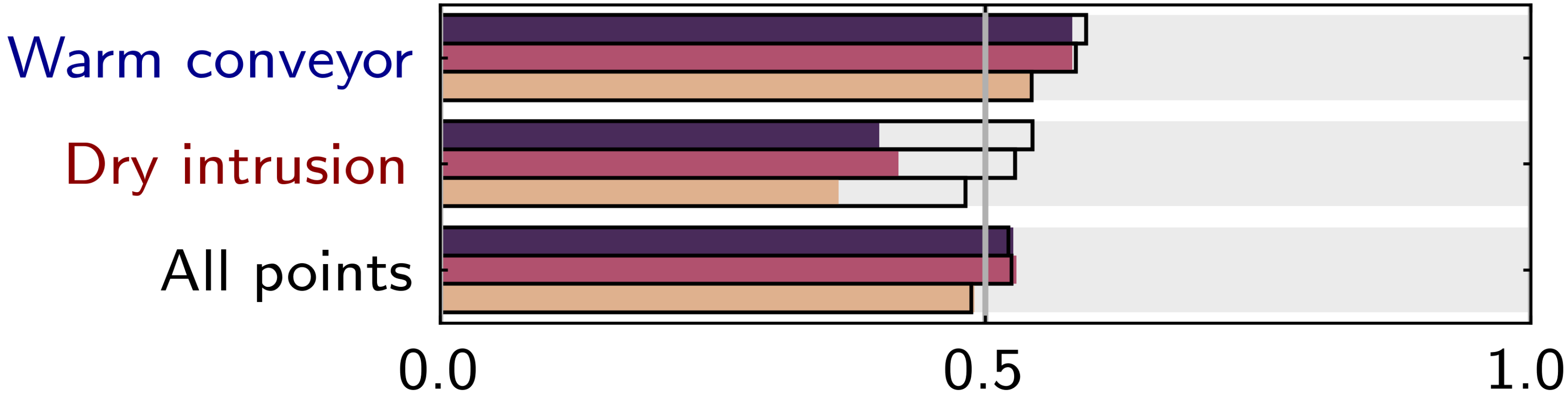
Composited IAGOS observations confirm the typical structure



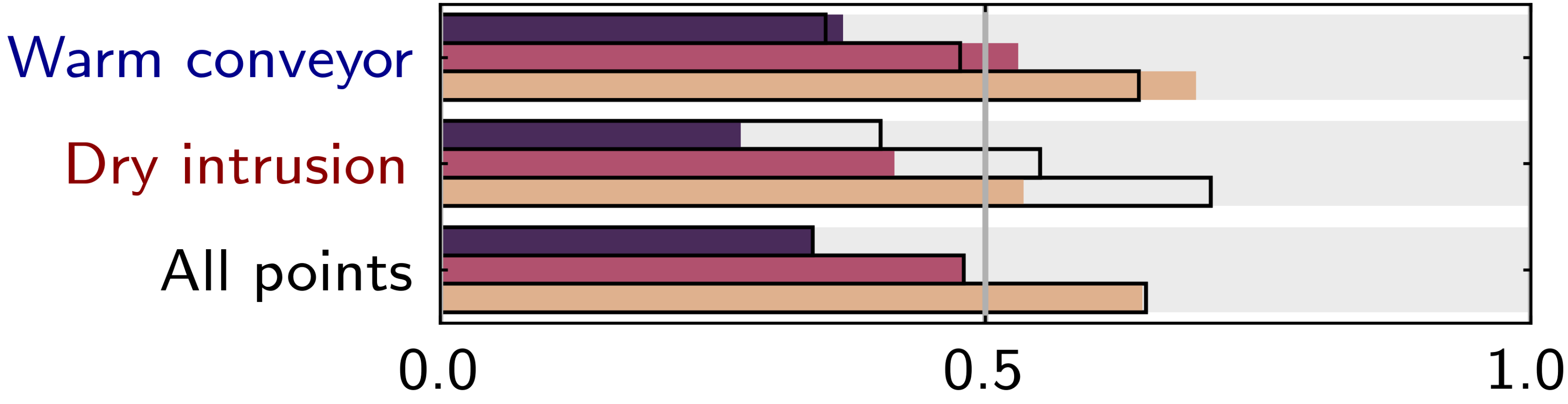
Where does disagreement in ISSR forecasting occur

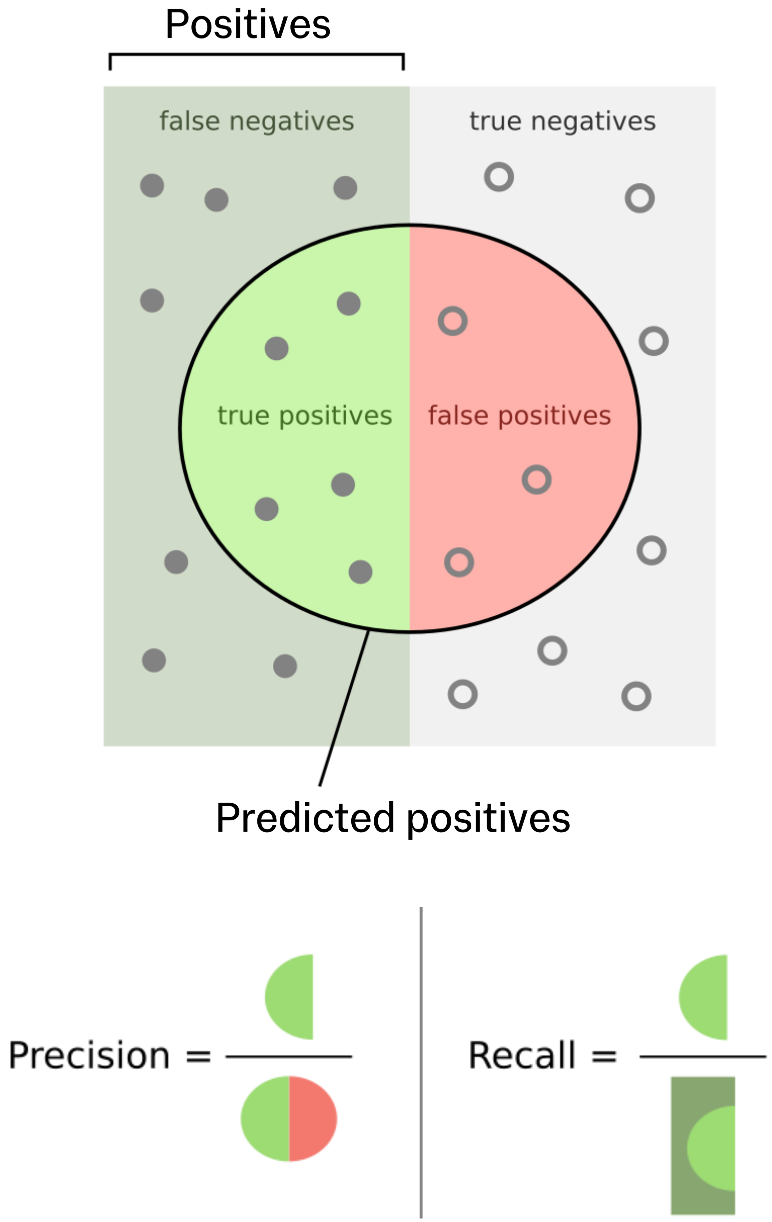
Calculating precision and recall

Precision (confidence)



Recall (comprehensiveness)





Black lines = the "counterfactual" — reference state of typical weather.
Humidity scaled: ISSRs at 90%, 97.79% (Teoh et al. 2022), 100% RHi

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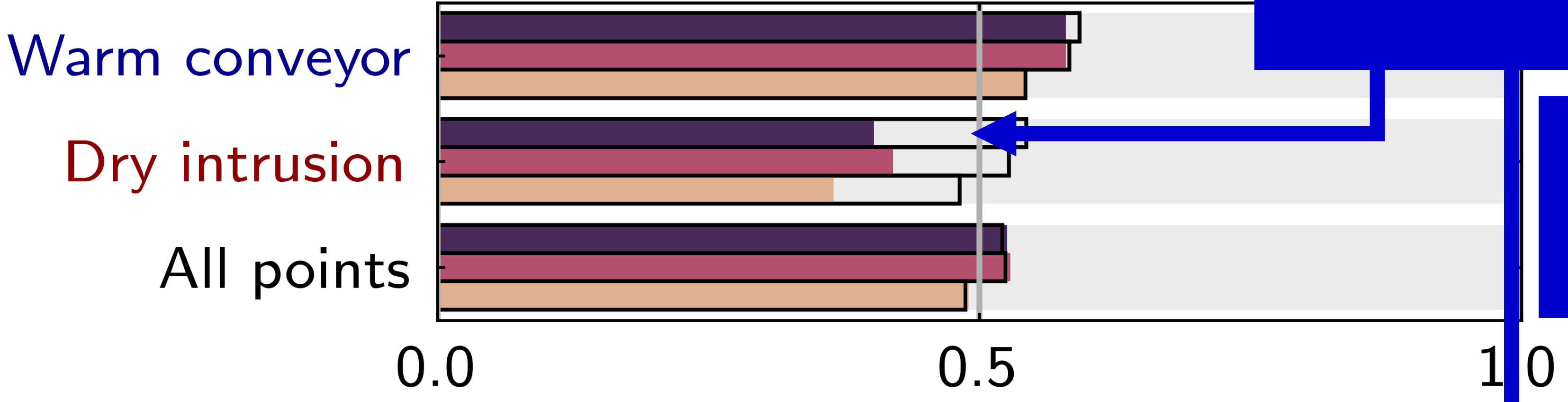

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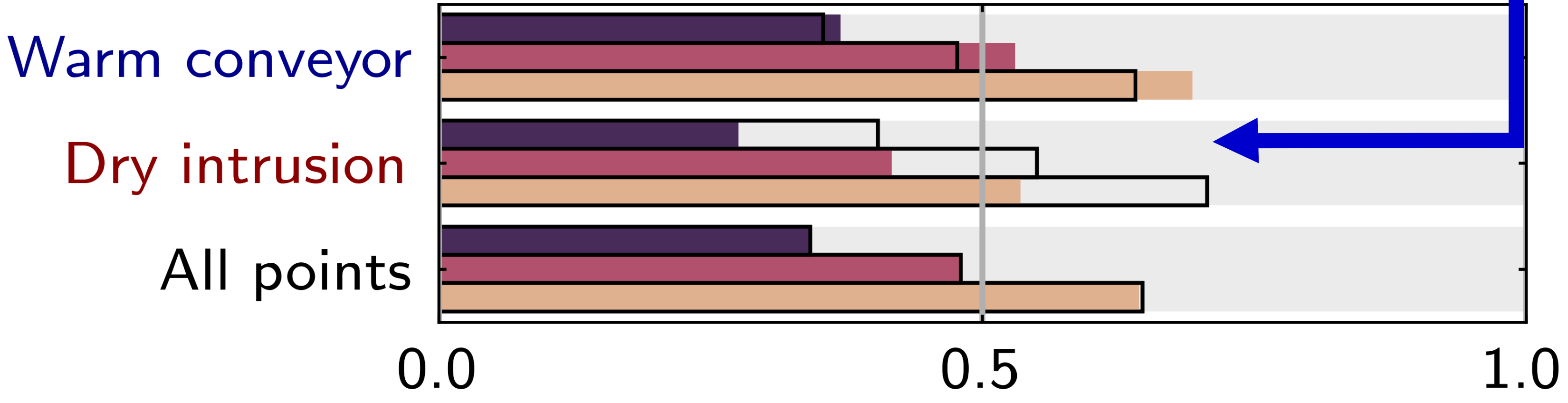
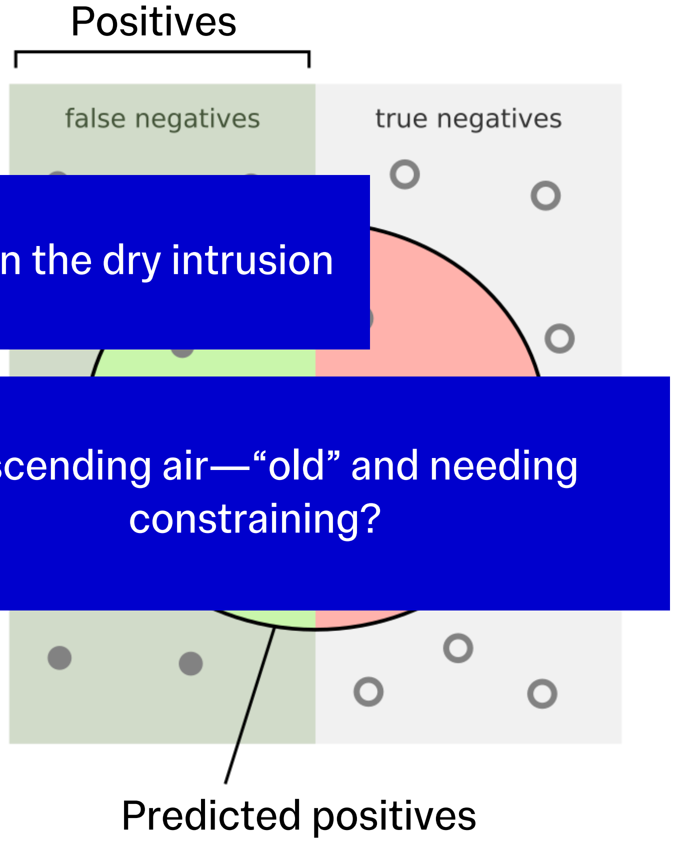


Performance is worse in the dry intrusion

Descending air—“old” and needing constraining?



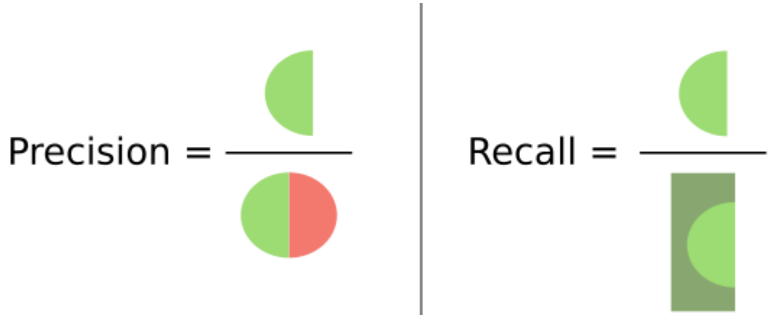


Diagram representation of precision and recall by Walber. Reproduced under CC-BY 4.0.

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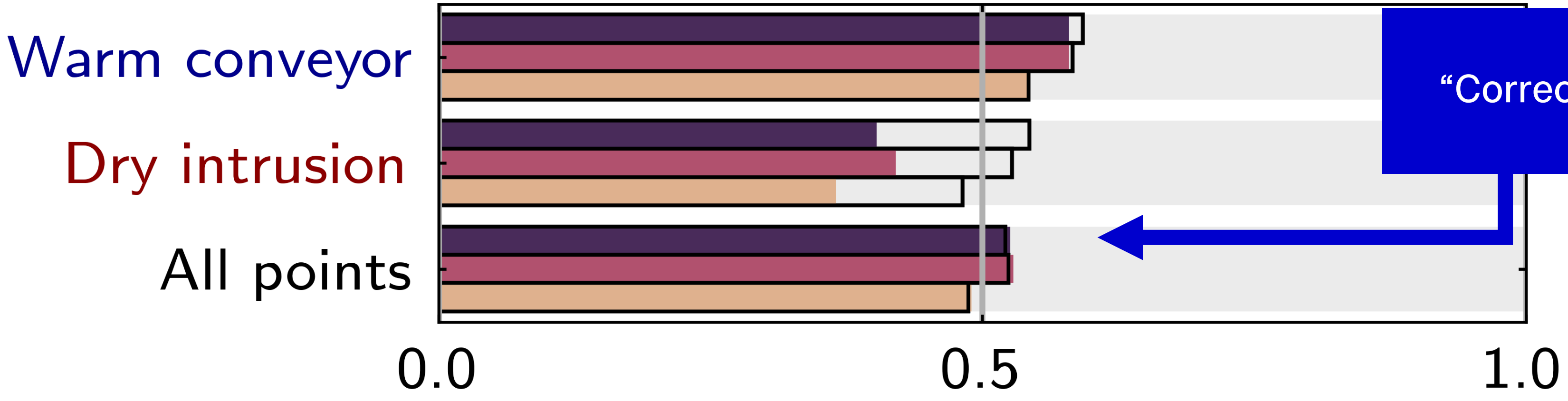
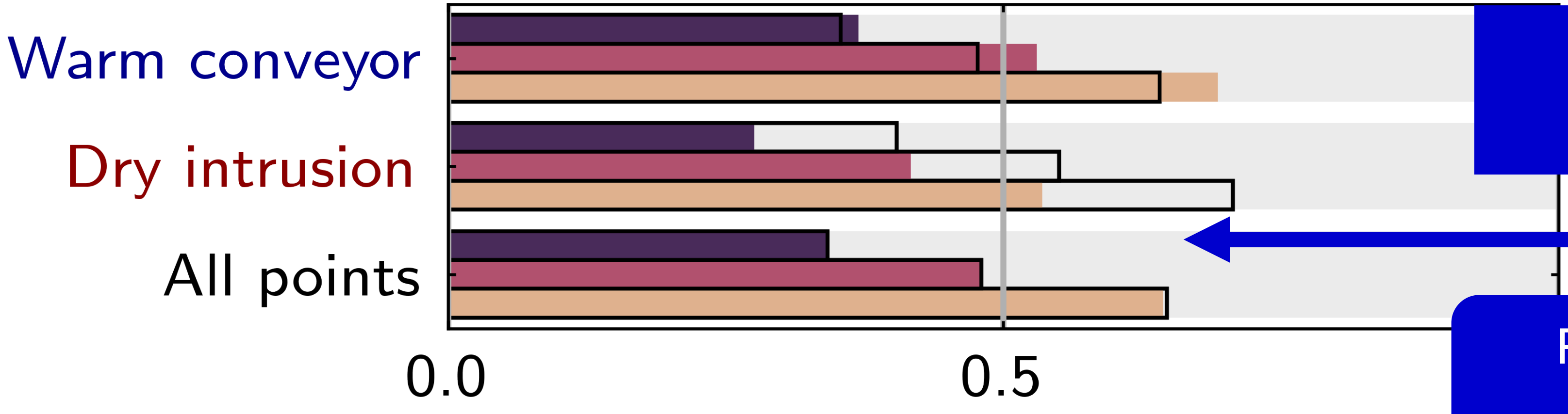
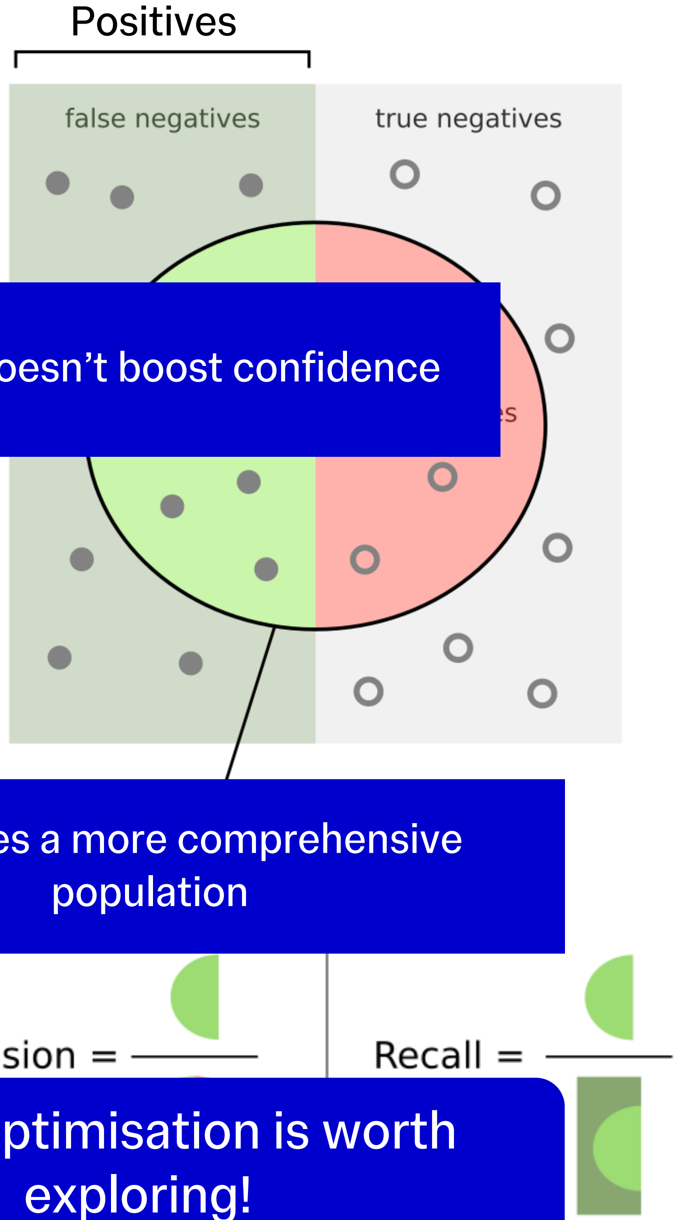


Recall (comprehensiveness)





"Correction" doesn't boost confidence

but makes a more comprehensive population

Recall optimisation is worth exploring!

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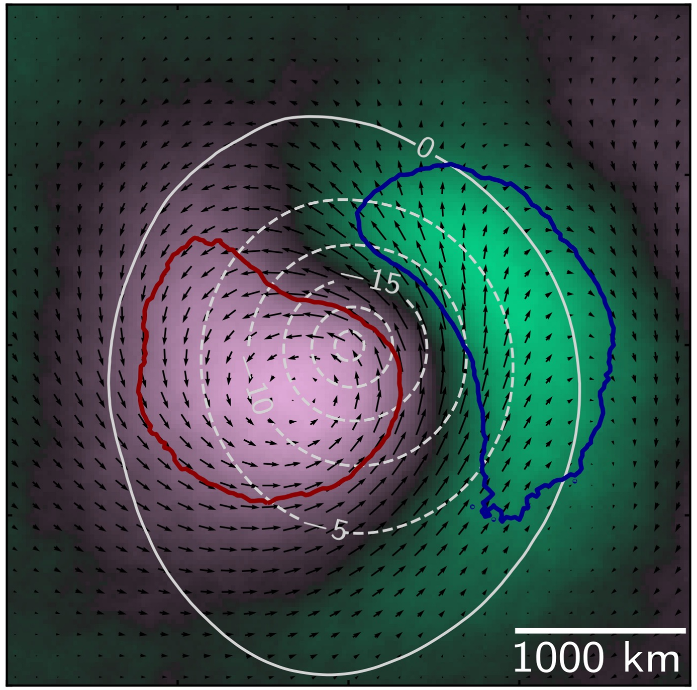
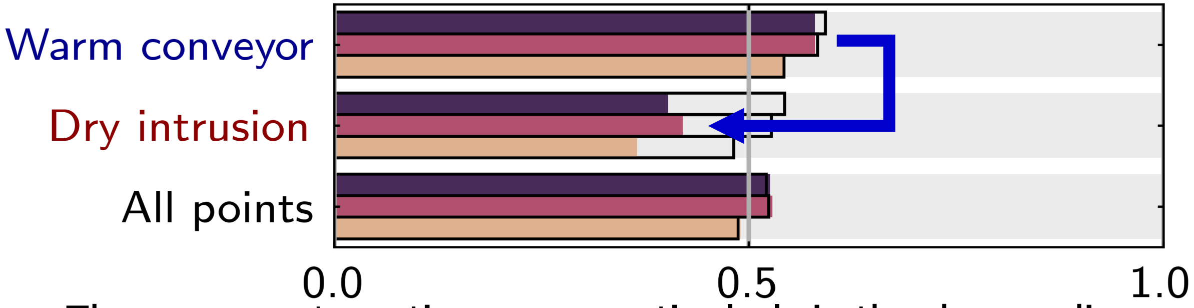
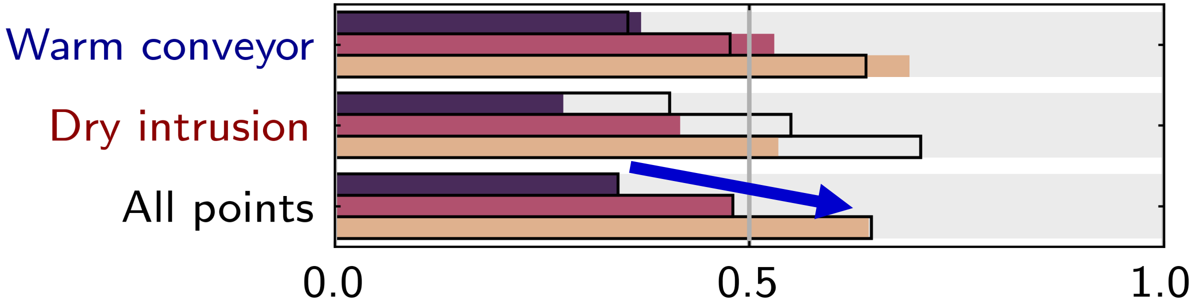


ISSRs are strongly structured in storms of the North Atlantic



There are systematic errors, particularly in the descending air, that need to be constrained by observations.



Scaling past “correction” continues the improvements. Underlines the need to optimise for your own aims.

Read the preprint for more, including air traffic density and CoCiP outputs (revisions are imminent).

Also talk to me about satellite observability or ground observations!

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