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Radon-222 measurements at the Northern Territory Baseline Air Pollution Station

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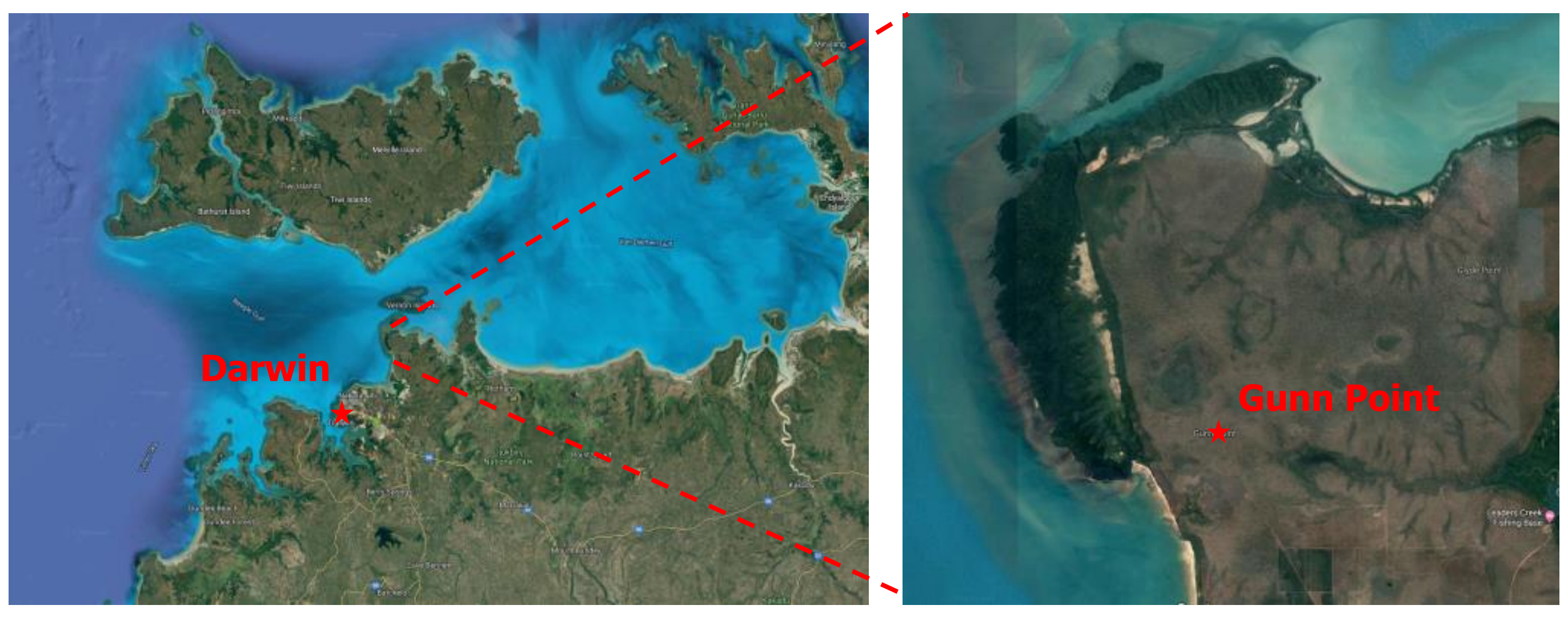
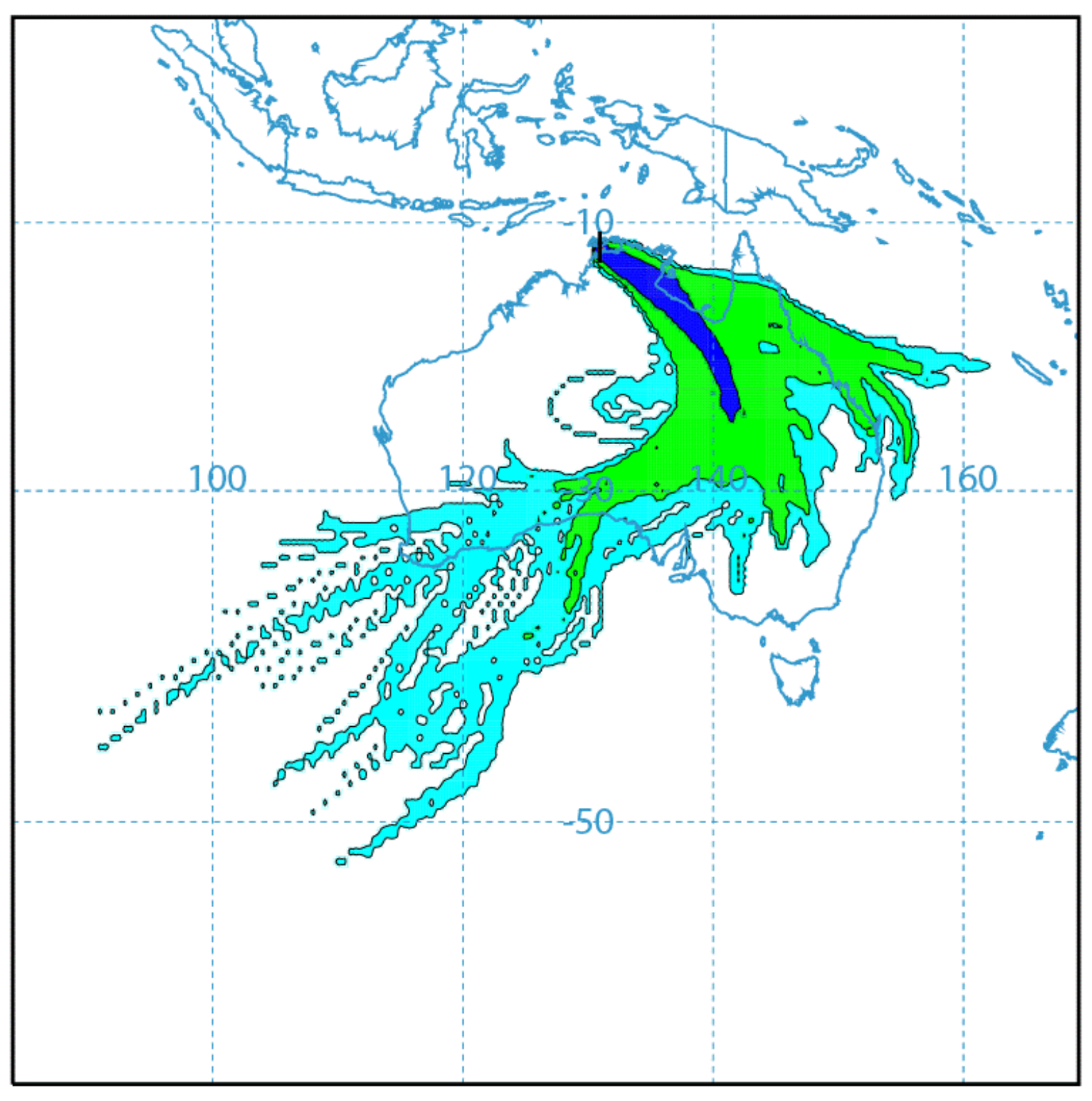
Global "baseline" stations specialise in monitoring long-term regional or hemispheric-mean changes in anthropogenic emissions that have the potential to alter climate or adversely affect the environment. This ability is contingent upon reliably identifying well-mixed air masses that have been removed from localized pollution sources for a long time. Radon provides a convenient, consistent, effective alternative to conventional meteorological approaches for baseline air mass identification.

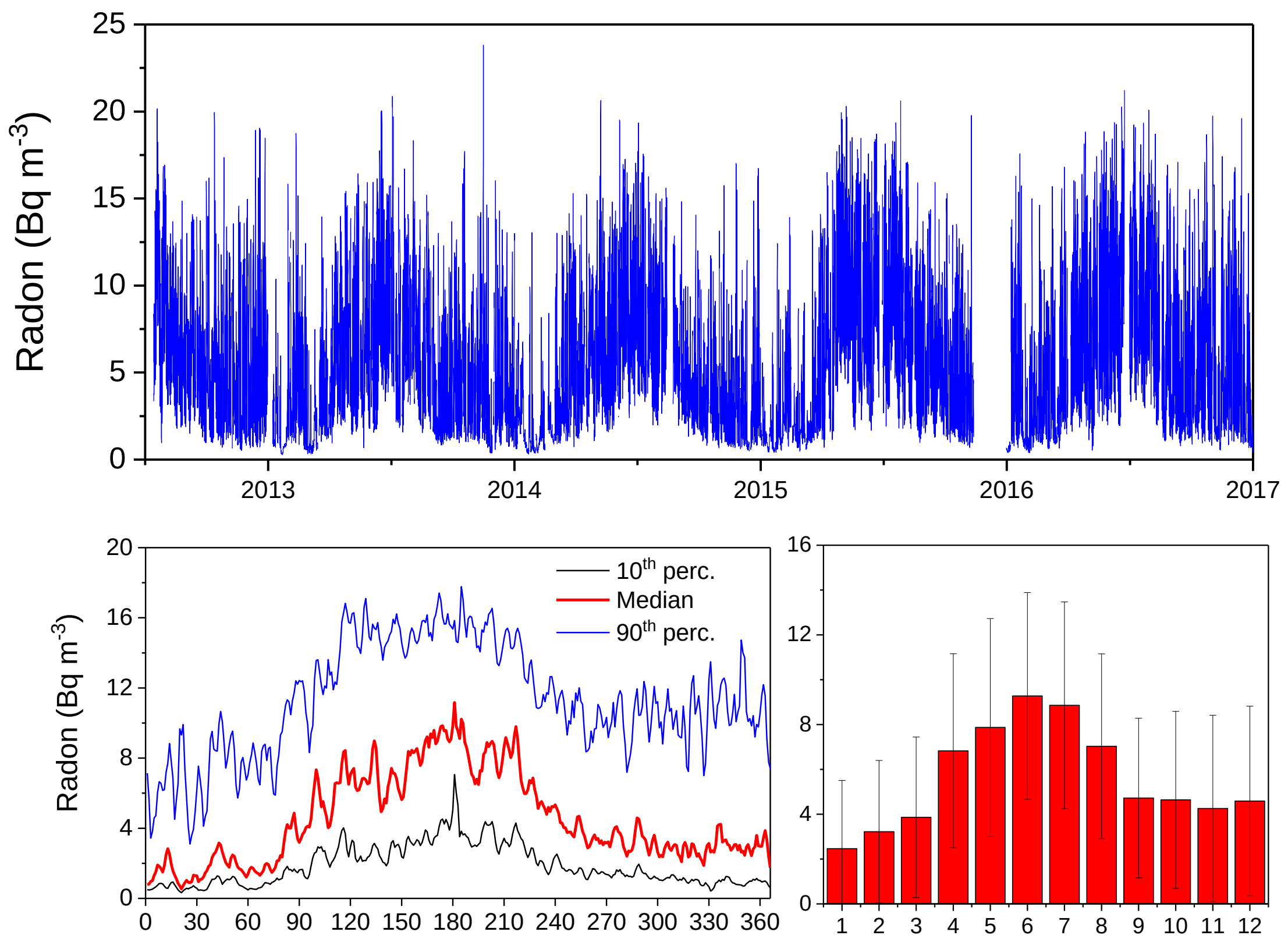


The Gunn Point NT BAPS site is 36km NE of Darwin. The nearest oceanic fetch is 2-3 km to the west. Within the sector 260-290° the potential exists for extended oceanic fetch. Radon is measured at NT BAPS using a 700 L dual flow loop two filter detector designed and built at ANSTO (e.g. Griffiths et al. 2016).

Radon and "Baseline" Monitoring

^{222}Rn is a naturally-occurring, unreactive, radioactive gas that is not prone to washout or aerosol attachment. Since it has a well-constrained, predominantly terrestrial source, radon is a convenient tracer for air mass interaction with the land surface (where most pollution sources are located). It's half-life (3.8d) enables radon to be used as an indicator of terrestrial influence on air for ≤3 weeks (Chambers et al. 2016). Over the open ocean radon concentrations are around 0.05 Bq m^{-3}. In conjunction with back-trajectories, radon is an effective tool for constraining fetch regions that influence observations of most atmospheric trace species. **To the right** is a trajectory density plot of all air masses in the tropical "dry season" with radon concentrations >0.5 Bq m^{-3} (e.g. Mallet et al. 2017).

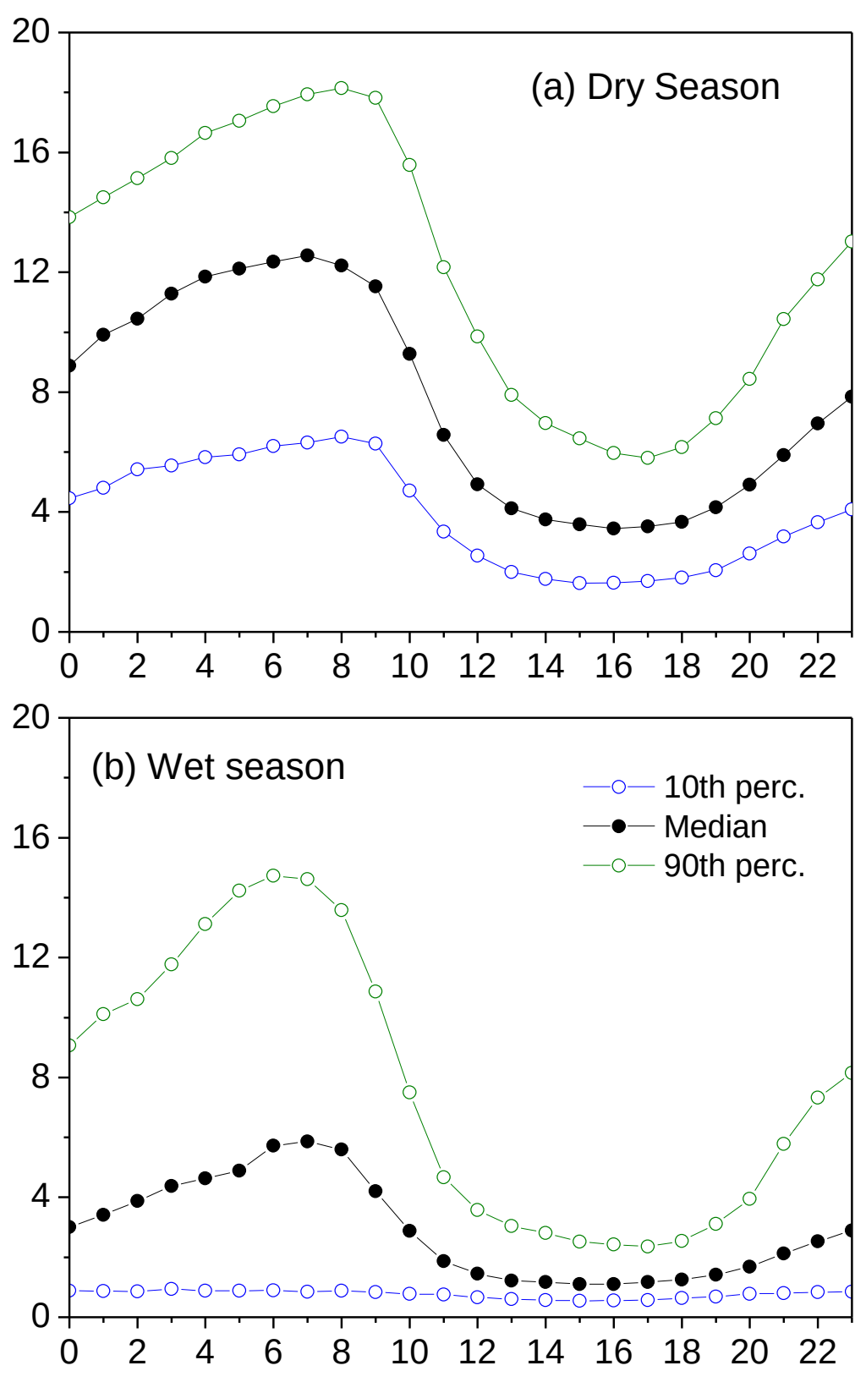


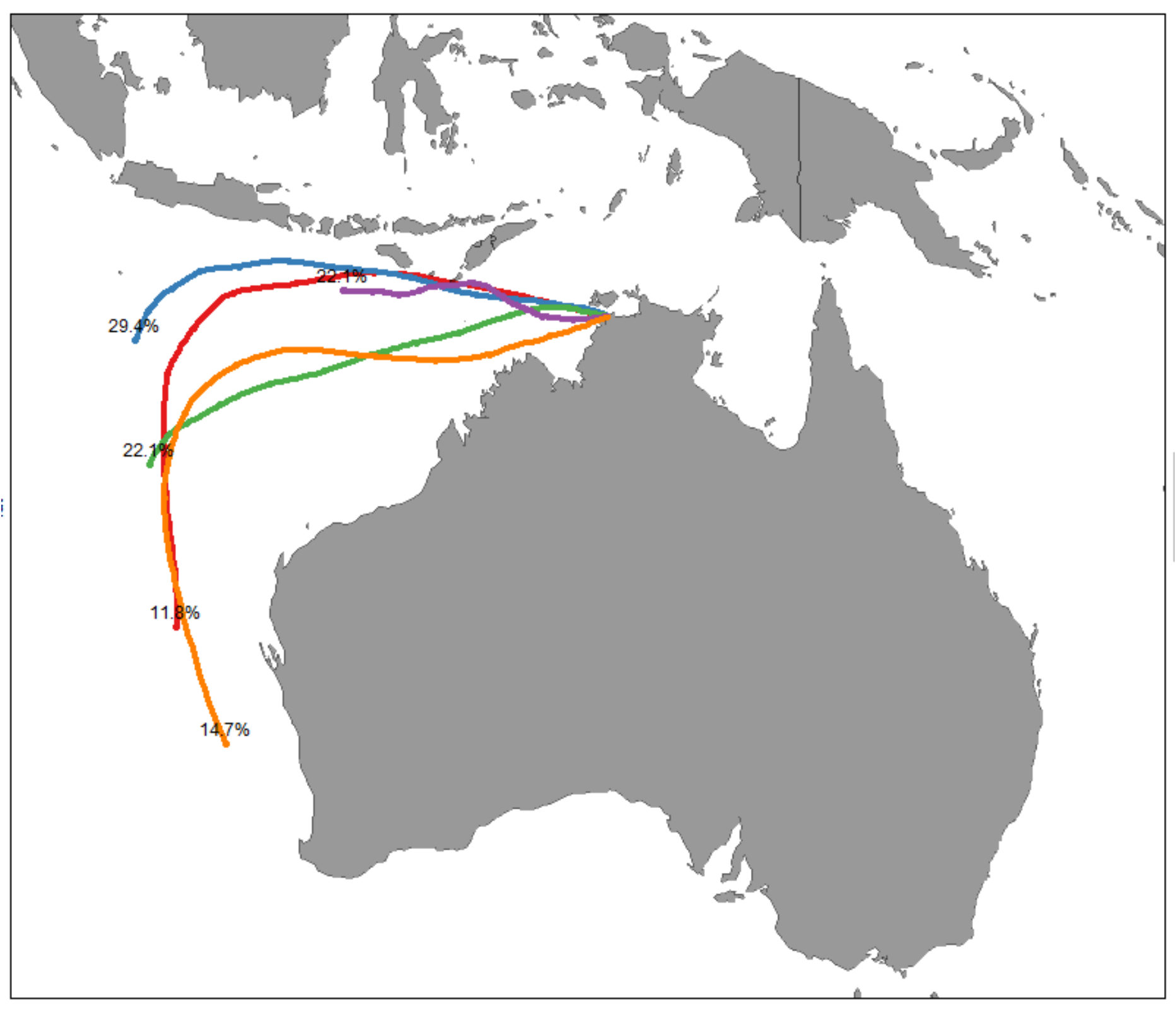


Seasonal radon characteristics at the Gunn Point Observatory

The **top left panel** shows 4.5 years of hourly radon observations at NT BAPS. A seasonal cycle is evident, shown more clearly in the daily and monthly composite plots of the **lower two panels**. The radon seasonal cycle is characterised by maximum concentrations during the winter monsoon (when air is predominantly moving offshore from the Australian continent) and minimum concentrations during the summer monsoon (when air is predominantly moving onshore from the ocean).

The **right hand panels** show diurnal radon cycles in the "dry" (winter) and "wet" (summer) monsoonal seasons. Diurnal cycles are typically characterised by a morning maximum and afternoon minimum, driven by diurnal changes in the mixing depth of the atmospheric boundary layer. The 10th percentile values in summer show very little diurnal variability since these air masses are coming directly from the ocean. Because of the 2-6km of land fetch west and north of the station, minimum radon in summer under oceanic fetch conditions ranges from 0.3 - 0.9 Bq m^{-3}.

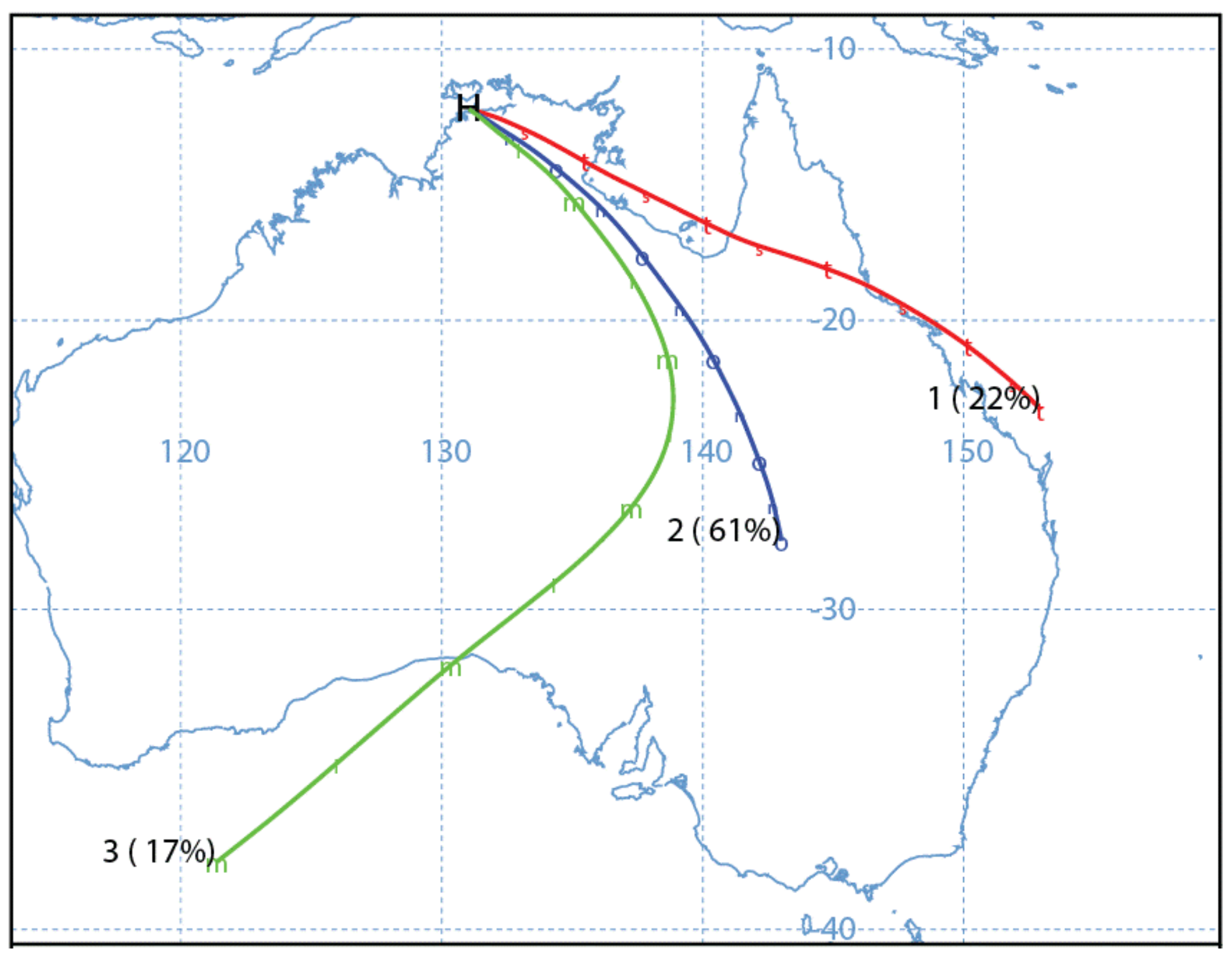


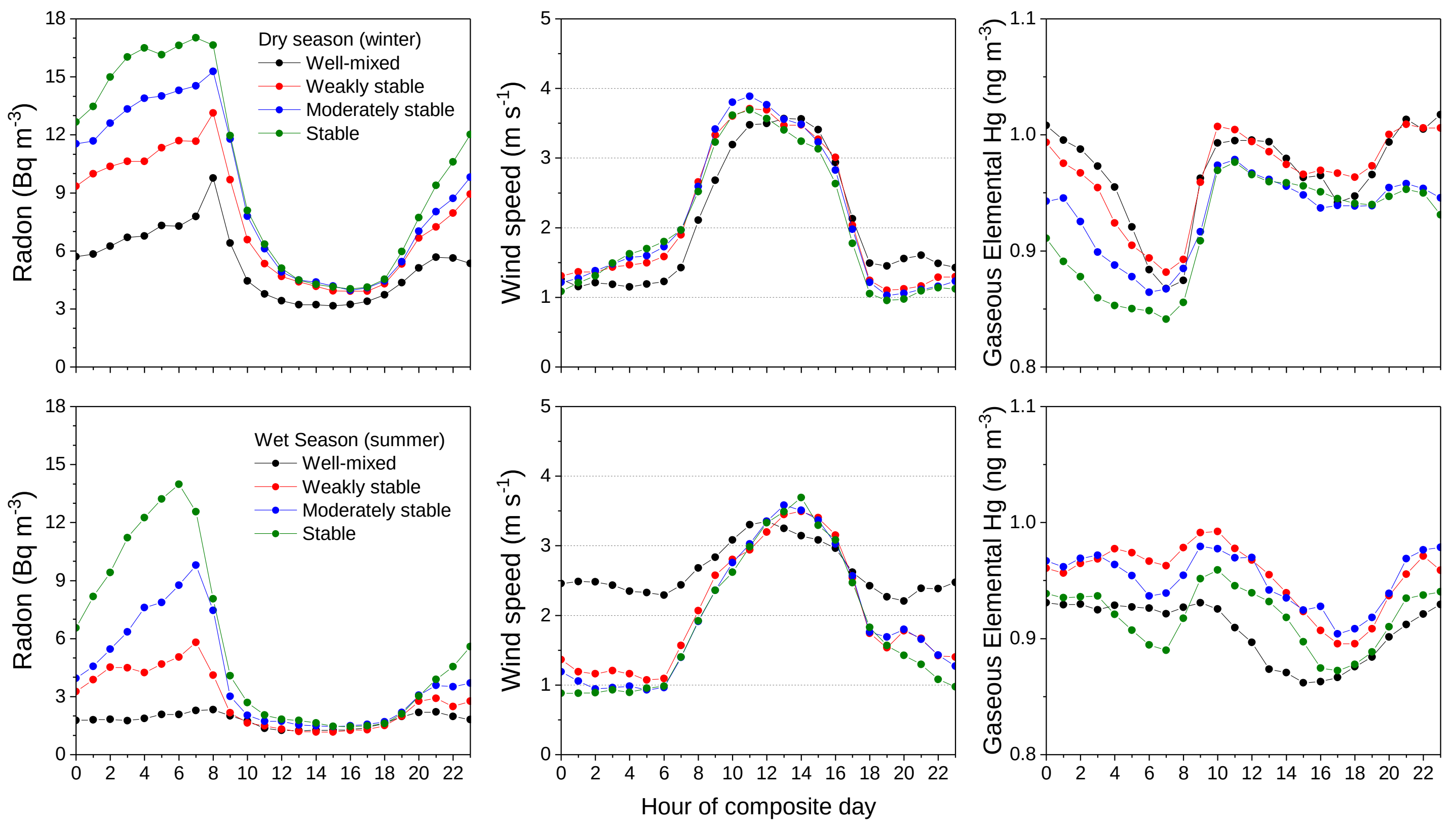


Dominant Monsoonal Fetch Regions

The **left hand panel** is a trajectory cluster analysis plot for summer monsoonal air masses arriving at NT BAPS with radon concentrations less than 0.9 Bq m^{-3}. The fetch regions represented change markedly with mean wind speed, but all have spend an extended period free of terrestrial influences.

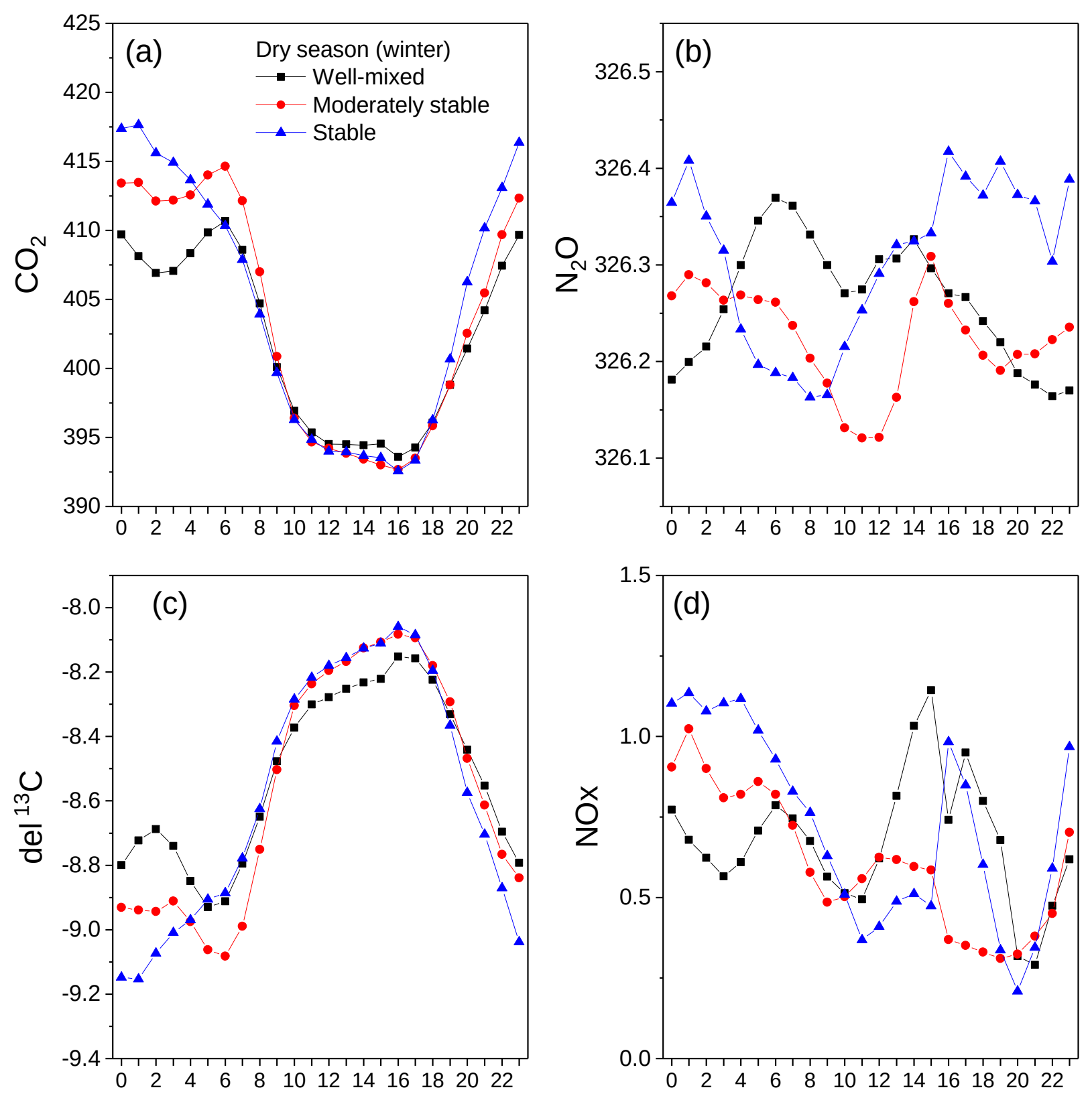
The **right hand panel** is a trajectory cluster analysis plot for winter monsoonal air masses arriving at NT BAPS with radon concentrations greater than 0.9 Bq m^{-3}. Clearly, the prevailing synoptic situation has a large bearing on the fetch regions of high-radon winter air masses. The atmospheric composition of air masses from each of these fetch regions will likely be quite distinct. A statistical analysis of radon concentrations within each of these clusters can provide information about air mass connectivity with the surface.





Surface-Atmosphere Interaction

Nocturnal radon accumulation can be used to characterise stability within the nocturnal boundary layer – which influences surface-atmosphere interactions and trace gas concentrations near the surface. The **left hand panels** show that small changes in nocturnal wind speed can have a large impact on near surface radon accumulation. Atmospheric conditions associated with these changes in wind speed also impact near surface concentrations of trace gases (e.g. *Chambers et al. 2015; Williams et al. 2016*), as well as chemical processes (such as the capture and release of gaseous elemental mercury, Hg; *Howard et al. 2017*) at the surface-atmosphere interface. The **right hand panels** show increased CO$_2$ and NOx under stable nocturnal conditions, and strong diurnal change in the CO$_2$ Carbon-13 signature.



References: **Chambers SD**, and co-authors. 'On the use of radon for quantifying the effects of atmospheric stability on urban emissions', *Atmos. Chem. Phys.*, 15, 1175–1190, 2015; **Griffiths AD**, and co-authors. 'Increasing the accuracy and temporal resolution of two-filter radon–222 measurements by correcting for the instrument response', *Atmos. Meas. Tech.*, 9, 2689-2707, 2016; **Howard D**, and co-authors. 'Atmospheric mercury in the southern hemisphere tropics: seasonal and diurnal variations and influence of inter-hemispheric transport', Atmos. Chem. Phys., 17, 11623-11636, 2017; **Mallet M**, and co-authors. 'Biomass burning emissions in north Australia during the early dry season: an overview of the 2014 SAFIRED campaign', *Atmos. Chem. Phys.*, 17, 13681-13697, 2017; **Williams AG**, and co-authors. 'Radon as a tracer of atmospheric influences on traffic-related air pollution in a small inland city', Tellus B 68, 30967, http://dx.doi.org/10.3402/tellusb.v68.30967, 2016.

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