SAMPLE

Earth's Dynamic Systems: The Jet Stream

Rivers in the Sky

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Introduction

There is a river in the sky over nearly everyone's head. It has no water in it, only air, and it flows not at ground level but ten kilometers up, at the ceiling of the weather's world, in a current hundreds of kilometers wide and a few thick, moving at the speed of an express train and sometimes far faster. It is the jet stream, and it is not one river but a family of them: the polar jet that girdles each hemisphere in the middle latitudes, the subtropical jet that rides higher over the deserts, and a set of lesser currents at other heights and latitudes, all of them born from the same cause, the temperature contrast between the warm tropics and the cold poles, and all of them doing the same work, carrying the atmosphere's surplus westward-spinning momentum in the fastest lanes the planet owns.

The jet stream's story is one of the atmosphere's strangest: for most of history nobody knew it existed, because nobody had ever been high enough or instrumented enough to see it; it was found all at once, by the pilots of the Second World War, who met it as an enemy, a wind that could hold a loaded bomber still against its own full power, and by the meteorologists who finally mapped it with the wartime's balloon data; and within a generation of its discovery it had become the weather's master key, the current that steers storms, that explains droughts and floods when it stalls, that sets the airline schedules and the turbulence warnings of the flying age. The river in the sky turned out to run everything, and this book is its account.

The chapters are built for the general reader, with no mathematics. They open with the discovery and the atmosphere's layered structure that makes the river possible; they follow the physics that builds the jets and the geography of where the currents run; they follow the river's moods, its meanders and stalls and splits, and its grip on the weather of the whole temperate world; and they close with the jets' higher cousins in the stratosphere, the modern observation networks that watch them, the question of what a changing climate is doing to them, and the rivers in the skies of other planets, where the same physics builds currents that dwarf the Earth's. One river, many rivers, one physics: the account that follows is the story of the fastest winds on the planet and of the slow ideas that finally caught them.

Chapter 1: Found by War

The river in the sky was discovered by accident, in the middle of the twentieth century, by people trying to kill each other. The pilots of the high-altitude bomber fleets, flying the great piston aircraft of the 1940s at the edge of their ceilings, began to report a strange and dangerous behavior: a wind, at altitude, so strong that a formation flying east could ride it like a conveyor while a formation flying west could hang nearly still, ground speed halved or worse, gas burning and bombers drifting backward relative to the ground. The reports accumulated through the war's high-altitude operations, over Europe and over the Pacific, and the air forces did what institutions do with an inconvenient physical fact: they routed around it, and quietly set their meteorologists to find it.

The finders had the material of a century and did not know it. Since the late nineteenth century, kite and balloon observations had been climbing into the upper air; the eruption of Krakatoa in 1883, scattering its smoke around the world, had left observers noting that high clouds traveled implausibly fast; the discovery of the stratosphere itself, at the opening of the twentieth century, had come from instrumented balloons; and the between-the-wars years had seen a scattering of soundings and a few solo pilots, the pioneer aviators of the stratospheric suits, flying in the high wind lanes and living to describe them.

But the data was scattered, the heights were exceptional, and the idea of a planetary river, persistent, coherent, girdling the globe, did not crystallize until the war's operational demand forced the synthesis: the balloon network of the 1940s, launched to aim bombs, mapped the winds aloft over whole hemispheres, and the maps showed the unmistakable signature, cores of wind in long bands, at the tropopause's height, racing west to east.

Two wartime footnotes belong in the discovery's record, because they are the river's own demonstrations. The first is the Japanese balloon campaign of the war's last years: thousands of paper balloons, lofted into the winter jet stream with incendiary payloads, rode the current across the Pacific to North America, the only intercontinental weapon of the war, and their designers' knowledge of the river, gathered from the sparse pre-war soundings of the Pacific, was precise enough to deliver a measurable fraction of them to the continent. The second is the war's final year of high-altitude bombing, when the jet's grip on the great piston aircraft over Japan, the world's strongest and most consistent jet core, forced the air fleet's missions lower, and the operational doctrine of an entire campaign was rewritten by a wind nobody had mapped ten years earlier.

The river had been there for four billion years; the species had found it in the course of a war, and the finding, like the river itself, would now never be lost.

The discovery's aftermath deserves a sentence before the physics begins: within a decade, the jet stream was the organizing fact of the new numerical meteorology, the key current of the emerging global observation network, and the public's new shorthand for the upper air; the airlines were timing their crossings by it within a generation; and the phrase the jet stream, coined in the war's data rooms, had entered every language of the flying world. The river in the sky had a name, and the chapters that follow explain what it is, why it runs, and why the weather of everyone's week goes where it goes.

The peacetime confirmation deserves the closing paragraph of the discovery's chapter. Within a few years of the war's end, the daily balloon soundings of the new international networks were mapping the river routinely, the wartime secret becoming the weather services' ordinary data, and the name coined in the data rooms, the jet stream, passed into the public language along with the science; the meteorologists of the era, writing the first textbooks of the upper air, gave the river its formal climatology, its two main currents, its seasons, and its storm-steering role, within a single decade of its operational discovery. The speed of the assimilation is worth a sentence of wonder: a current of the atmosphere that no scientist had named in 1939 was, by 1959, a household word and a routine analysis, the fastest a major natural phenomenon has ever traveled from first measurement to common knowledge, an honor the river owes to the war that found it and the flying age that immediately moved in beside it.

The balloon weapon's details are worth one more paragraph, because the campaign is a case study in the river's operational use. The paper spheres, lifted by hydrogen in the winter evenings, carried timers to release their sandbags at altitude, ascending into the river by calculation and descending over North America by clockwork; the design's success rate, perhaps one in ten reaching the continent, was achieved with the pre-war soundings' climatology alone, the statistical river rather than the daily one, and the campaign's military effect was negligible but its scientific one was not: the recovery of the balloons across a continent forced the acknowledgment, in the open literature of the peace, that a current existed that could deliver an unpowered object across the Pacific in three days, and the peacetime papers that told the story did the public discovery's work. The weapon had ridden the river; the peace mapped it; and the meteorologists' wartime conclusion became the textbook's first line.

The war's strangest passenger deserves the closing paragraph, because the

enemy found a use for the river before the ally finished mapping it. In the last years of the Pacific war, the engineers on the far shore designed and flew unmanned paper balloons, gas-filled, carrying incendiary bombs, and launched them by the thousands into the mid-latitude river to ride the jet east across the whole Pacific, the first intercontinental weapon in history being a balloon lofted onto the newly discovered current, the descent timed by an altimeter's releasing ballast through the crossing. The campaign's military weight was negligible, the forest fires it hoped to start rarely caught, the landings scattered over a continent's wilderness, but the flight physics was flawless: the balloons that were found, from Alaska to the mid-west, had ridden the jet for days, and the episode stands in this book's first chapter as the discovery's mirror image, the Allies meeting the river as a navigational enemy while the same wind, on the far side of the same war, was carrying the enemy's own weapons across an ocean, the current serving both sides with the same indifference.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.